EEAP/WSMR

ENERGY ENGINEERING ANALYSIS PROGRAM
WHITE SANDS MISSILE RANGE, NEW MEXICO

DEPARTMENT OF THE ARMY - CORPS OF ENGINEERS
FORT WORTH DISTRICT - FORT WORTH, TEXAS
CONTRACT DACA63-81-C-0104

SOUTHWESTERN ENERGY GROUP
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FINAL REPORT
AUGUST, 1984

EXECUTIVE SUMMARY

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
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FINAL REPORT
EXECUTIVE SUMMARY

Prepared for

DEPARTMENT OF THE ARMY - CORPS OF ENGINEERS
Fort Worth District - Fort Worth, Texas

Under Contract No. DACA63-81-C-0104
Revised Scope 22 January 1982

Prepared by

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August 1984

EXECUTIVE SUMMARY

ENERGY ENGINEERING ANALYSIS PROGRAM (EEAP)
WHITE SANDS MISSILE RANGE
NEW MEXICO

INTRODUCTION

The primary objective of the Energy Engineering Analysis Program at WSMR is to identify and evaluate the major problematic areas of energy consumption and develop a comprehensive plan of action which would result in the reduction of energy consumption in compliance with the objectives set forth in the Army Facilities Energy Plan dated 1 October 1978, revised 26 October 1981. The long range objective is to implement such a plan which will make WSMR as energy efficient as the state of the art of energy conservation will allow.

The Scope of Work for this contract is divided into five increments: A, B, C, F and G. These increments are defined in the Scope as follows:

"Increment A projects involve modifying, improving or retrofitting existing buildings, including family housing, to include architectural and structural features, HVAC systems, plumbing systems, interior or exterior building and parking facilities lighting.

Increment B projects involve utilities and energy distribution systems, Energy Monitoring and Control Systems (EMCS) for building and distribution systems, and existing energy plants.

Increment C (Geothermal and Solar only) projects involve renewable energy projects. Although not strictly a renewable energy source, Geothermal shall be considered among the alternatives. The project will determine the feasibility of utilizing Solar and Geothermal for space heating, space cooling, domestic hot water or process heat, or combinations thereof. Programming documents are required (DD Forms 1391 and PDBs) for feasible projects.

Increment F will provide recommendations for systems modifications and changes in systems operations which are within Facilities Engineering funding authority and management control.

Increment G projects are those developed in Increments A & B which do not qualify under the ECIP criteria."

During the course of this study, all components of WSMR energy consumption were examined, however, the focus of attention was primarily directed toward the electrical, natural gas and propane consumption used for HVAC systems operations, DHW and process heating requirements and lighting energy. The energy conservation measures outlined in this report are aimed at reducing the energy consumption in these related areas.

The electrical consumption and power demand undoubtedly remains the highest order of concern at WSMR. Unfortunately, due to the very nature of this Installation, a great deal of this electrical consumption simply cannot be reduced because of the process electrical requirements (computer facilities, telemetry stations, telecommunications networks, radar equipment, etc.) which are necessarily utilized year round on a 24 hour basis to support the thousands of missions which take place at WSMR annually.

White Sands Missile Range is America's largest instrumented missile range operated by the U.S. Army. Established on 9 July 1945, WSMR's first test was the explosion of the world's first atomic device. Missile testing was started on 26 September 1945 and continues today. WSMR encompasses 4,000 square miles, including the White Sands National Monument. The headquarters of WSMR are located approximately 47 miles southwest of Alamogordo, New Mexico and 55 miles north of El Paso, Texas.

WSMR is a complex of personnel, support facilities, and range instrumentation designed to support the research, development, testing, and evaluation of weapons and space systems. The facilities of WSMR are available to all U.S. military departments, Government agencies, and authorized non-Government agencies, as well as foreign governments.

DATA BASE FOR ANALYSIS

The study was initiated in FY 1981 commencing with the collection of all raw data and pertinent information which was deemed necessary in order to establish an accurate and meaningful data base from which various data components could be easily accessed for technical applications and analyses. During this phase of data collection the following tasks were undertaken:

- Collection of all available recent historical energy consumption records, selective metering of specific facilities, monitoring of current energy use at existing meters.
- Collection of all available information from similar energy conservation studies conducted previously at WSMR and/or other military installations to provide guidance in developing this report.
- Collection of weather and climatological data for the area and determination of a Typical Meteorological Year (TMY) for computer simulation purposes.
- Conduction of field audits to gather concise input data for analysis purposes. Two independent auditing operations were performed: (1) an architectural audit to gather all building envelope and related data; (2) an HVAC audit to collect data describing in detail the various HVAC systems and system components information including heating and cooling primary and delivery systems, COP's, hours of operation, system types, etc.

- Selection and validation of a micro-computer program to be used as an analytical tool for modeling buildings' energy loads and consumption as well as a means of evaluating ECO viability using computer simulations.

- Development of computerized data bases which would allow easy access to significant information for analysis purposes. Three main data bases were developed:

  (1) Data Base A - "Summary of Building Function and Envelope Data" as found in Volume I, Section 2, pages 2-13 through 2-23, provides building function categories, envelope data and the number of occupants for each building which was selected to be audited.

  (2) Data Base B - "Summary of Building Equipment by Zone" as found in Volume I, Section 2, pages 2-27 through 2-40 provides information related to the buildings' HVAC systems, DHW equipment, lighting capacity, process energy and miscellaneous energy capacities.

  (3) Data Base C - "Summary of Building Loads and Energy Consumption" as found in Volume I, Section 3, pages 3-68 through 3-90 provides information critical to design analyses of ECOs and for energy balancing projections as found in Volume I, Section 3.8, pages 3-91 through 3-98. This data base breaks down the energy consumption of each building into select categories so that ECO's could be analyzed in greater detail with less difficulty.

- Examination of existing utilities distribution systems with the intent of improving these systems if at all possible.

- Preparation of a baseline assessment of energy consumption from FY 1975 to the present in order to identify target conservation areas.

- Identification, categorization and prioritization of Energy Conservation Opportunities (ECO's).

EXISTING ENERGY CONSUMPTION

The Army Facilities Energy Plan has assigned ECIP projects the goal of reducing energy consumption of existing buildings by at least 20% in FY85 using FY75 as a base year. To determine what quantitative energy consumption reductions are required to meet that goal, it was necessary to compile all historical (metered) utilities records from the base year, FY75 to the present which, at the time of the analysis, was FY81. The WSMR Energy Engineer, Mr. Joe Provencio, supplied Southwestern Energy Group with the WSMR utilities data summaries for electricity, natural gas, propane and bulk fuels. Southwestern Energy Group also obtained directly from the public utilities companies consumption data for the period beginning with calendar year 1974 through September 1981.

With few exceptions, most of the energy at WSMR is bulk metered by substation rather than by individual building. This presented problems in energy balancing and computer program verification since only a few buildings actually have their own utilities metered on site. The resolution of these problems is described in Volume I of this report under section 3.8, page 3-91.

The following data was made available for the base year, FY75.

WSMR Energy Consumption - FY 1975

- Electricity: 71,863,022 kWh (RIF)
  $1,733,935.53 cost
  833,611 MBtu (RUF)
- Natural Gas: 3,907,980 Therms (RUF)
  $254,649.56 cost
  390,798 MBtu (RUF)
- Propane (LPG): 581,989.5 Gallons (RIF)
  (FY 1975 cost not available)
  55,580 MBtu (RUF)
- Other Bulk Fuels (Vehicular uses not applicable)

Total Non-vehicular Energy Consumption: 1,279,989 MBtu

For the purpose of analyzing ECO's FY 1981 energy consumption was used as a basis for comparison. The following refers to FY 1981:

- Electricity: 70,470,243 kWh (RIF)
  $3,594,033.40 cost
  817,455 MBtu (RUF)
- Natural Gas: 2,818,120 Therms (RUF)
  $780,926.46 cost
  281,812 MBtu (RUF)
- Propane (LPG): 447,204.2 Gallons (RIF)
  $287,552.3 cost
  42,708 MBtu (RUF)
- Misc. Non-Accountable Energy: 21,692 MBtu (RUF)

Total Non-vehicular Energy Consumption: 1,141,975 MBtu

Using the data given for FY 1975 we can estimate how much energy savings are required by the years FY 1985 and FY 2000 in order for WSMR to comply with the goals set forth in the Army Facilities Energy Plan, dated October 1978, revised 26 October 1981, which, in section 1.1 clearly states that Army conservation goals are to:

"Reduce baseline FY 1975 total facilities energy consumption (Btu) - 20 percent by FY 1985 and 40 percent by FY 2000".

Then, using FY 1985 total non-vehicular energy consumption (in source, RUF values), we establish our energy savings requirements as follows:

(1) To reduce consumption by 20% by FY 1985, we require energy savings of:

0.20 (1,279,989) MBtu/yr. = 255,997.8 MBtu/yr.

or, to project total non-vehicular energy consumption for FY 1985:

0.80 (1,279,989) MBtu/yr. = 1,023,991.2 MBtu/yr.

(2) To reduce consumption by 40% by FY 2000, we require energy savings of:

0.40 (1,279,989) MBtu/yr. = 511,995.6 MBtu/yr.

and, to project total non-vehicular energy consumption for FY 2000:

0.60 (1,279,989) MBtu/yr. = 767,993.4 MBtu/yr.

A comprehensive report was prepared to compare the energy consumption accounted for by the computer simulations with the actual metered energy consumption recorded by the FE office at WSMR. The simulations included the Family Housing Area, 111 Post Area Buildings and a few upper range buildings which were selected to be audited and simulated. This report is in Volume I, Section 3.8, page 3-91. Refer to this section for a detailed analysis of the effectiveness of the computer simulations.

Source energy consumption was evaluated by building function categories and a comparison of usage was made. It became obvious that buildings which house different functional operations consume varying amounts of heating, cooling and process energy. For example, consider a high energy using computer facility such as building P00300, the Range Control Center. Typically, such a facility, with continuous 24 hour operation of large arrays of computer and related process electrical equipment, will use very little, if any, fuel energy for space heating since the heat generated by the heavy wattage electrical equipment is normally ample to meet the space heating requirements. The air conditioning (cooling) energy consumption on the other hand will typically be much higher than most facilities since it is required not only for comfort cooling during the cooling season but also for process equipment cooling which is required year round. This type of facility is not uncommon in the WSMR complex. Table ES-1 which follows summarizes the average energy requirements for each function category group based on simulation outputs generated for the Family Housing Area and 111 other WSMR buildings which were audited. It should be emphasized that the quantities listed in table ES-1 are averaged for each category and, due to the extreme variation in consumption from one building to the next (depending on each building's operational hours and functional characteristics), these

numbers should not be used to extend or project energy consumption to other buildings for analysis purposes. It should also be noted that WSMR is a very unique environment and that few buildings, even in the same function category, behave in similar ways since different operations are likely to be encountered in every building. With this in mind, let us examine the energy usage per building type.

SOURCE ENERGY CONSUMPTION BY BUILDING FUNCTION CATEGORY

Building Function Category	Source (RUF) Energy Consumption Total MBtu/yr.	Average MBtu/yr/sq.ft.	Percent of Energy
100 00 (Operational & Training)	45,794.7	0.409	6.06%
210 00 (Maintenance)	16,138.1	0.108	2.14%
310 00 (Research, Development & Testing)	327,289.9	0.388	43.33%
440 00 (Warehouses)	4,523.0	0.053	0.60%
500 00 (Medical Facilities)	29,944.8	0.509	3.96%
610 00 (Administrative)	76,929.3	0.143	10.19%
720 00 (Bachelor Housing)	41,229.2	0.162	5.46%
730 00 / 740 00 (Community Facilities)	44,779.2	0.196	5.93%
711 00 (Family Housing)	168,648.9	0.142	22.33%
TOTALS	755,277.1	0.218	100.00%

A comparison can now be made between the source (RUF) energy consumption per gross square foot of floor area as simulated by computer and the actual base-wide energy consumption per total base gross area as recorded by WSMR FE personnel. The total non-vehicular source energy consumption recorded for WSMR in FY 1981 yields:

$$\frac{1,163,667 \text{ MBtu/yr.}}{4,940,708 \text{ gross sq.ft.}} = 0.236 \frac{\text{MBtu/yr.}}{\text{sq.ft.}}$$

The deviation of the energy per square foot (as simulated) from the above represents the following percentage of error:

$$\frac{(0.236 - 0.218)}{0.236} \times 100 = 7.63\%$$

Page 3-95 of Volume I, Section 3.8 provides some justification for this error. EEAP criteria considers any such error which is less than 10 percent as reasonable and acceptable.

TYPICAL BUILDING ENERGY CONSUMPTION

As previously emphasized, WSMR facilities cannot readily be categorized into typical energy consumption groups due to the diversity of activities and functional operations which occur from one building to the next (even within the same function classification). However, in order to provide a general idea as to what kind of energy consumption characteristics are inherent in each function category, the following buildings were selected as typical examples for each function category.

1. Operational and Training (100 00):

Building P21903, TEL EXCH BLDG (13180)
Gross area = 7,038 sq.ft.; Environmental area = 6,667 sq.ft.

This building, located slightly up-range from the main Post area, serves as a communications support facility for a meteorological data collection facility known as "C" Station. It is occupied 24 hours a day, 5 days a week year-round. It incorporates 2 DX refrigerated air conditioners (approximtely 25 tons total capacity) with two large air handling units. Two water boilers (121.6 and 155.0 KBtu/hr. output capacity) supply the air handlers for hot water space heating. Electrical process equipment is fairly extensive but not always fully utilized.

Energy Consumption:

Heating consumption fuel (LPG):	189.3 MBtu/yr., RUF (0.028 MBtu/yr./sq.ft.)
Heating consumption electric:	2.9 MWH/yr. (0.005 MBtu/yr./sq.ft.)
Refrigeration cooling electric:	19.1 MWH/yr. (0.033 MBtu/yr./sq.ft.)
Lighting consumption electric:	69.6 MWH/yr. (0.121 MBtu/yr./sq.ft.)
Process consumption electric:	159.7 MWH/yr. (0.278 MBtu/yr./sq.ft.)
DHW consumption fuel (LPG):	15.7 MBtu/yr., RUF (0.002 MBtu/yr./sq.ft.)
Total fuel consumption:	205.0 MBtu/yr., RUF (0.031 MBtu/yr./sq.ft.)
Total electric consumption:	251.3 MWH/yr. (0.437 MBtu/yr./sq.ft.)
Total energy consumption:	3120.1 MBtu/yr., RUF (0.468 MBtu/yr./sq.ft.)

2. Maintenance (210 00):

Building P01794, ORD FLD MNT S (21430)
Gross area = 20,640 sq.ft.; Environmental area = 20,640 sq.ft.

This building is a good representative example of a WSMR maintenance facility. It is evaporatively cooled and space heating is provided by natural gas fired unit heaters.

Energy Consumption:

Heating consumption fuel (NG):	1,217.8 MBtu/yr., RUF (0.059 MBtu/yr./sq.ft.)
Heating consumption electric:	6.7 MWH/yr. (0.004 MBtu/yr./sq.ft.)
Evaporative cooling electric:	4.8 MWH/yr. (0.003 MBtu/yr./sq.ft.)
Lighting consumption electric:	51.6 MWH/yr. (0.029 MBtu/yr./sq.ft.)
Process consumption electric:	17.8 MWH/yr. (0.010 MBtu/yr./sq.ft.)
DHW consumption fuel (NG):	28.8 MBtu/yr., RUF (0.001 MBtu/yr./sq.ft.)
Misc. consumption electric:	5.6 MWH/yr. (0.003 MBtu/yr./sq.ft.)
Total fuel consumption (NG):	1,246.6 MBtu/yr., RUF (0.060 MBtu/yr./sq.ft.)
Total electric consumption:	86.5 MWH/yr. (0.049 MBtu/yr./sq.ft.)
Total energy consumption:	2,250.0 MBtu/yr., RUF (0.109 MBtu/yr./sq.ft.)

3. Research, Development and Testing (310 00):

Building P01534, ELCT EQP FAC (31034)
Gross area = 26,378 sq.ft.; Environmental area = 23,732 sq.ft.

Building P01534, located in the Tech Area on Post, is a good example of a typical R&D type facility where new equipment is researched and tested. Computer equipment is used daily and during 80 percent of the year most of the employeees work until 8:00 p.m., a semi-variable tour of 12 hours per day, 5 days per week year-round. This building has an evaporatively cooled zone and a refrigerated A/C zone. District steam for space heating is provided by nearby building S01544 and supplies two hot water convertors which service unit heaters and baseboard hydronic heaters in the evaporatively cooled zone and larger air handlers in the regrigerated zone.

Energy consumption:

Heating consumption fuel (NG): 360.9 MBtu/yr., RUF
(0.015 MBtu/yr./sq.ft.)

Heating consumption electric: 6.7 MWH/yr.
(0.003 MBtu/yr./sq.ft.)

Regrigeration cooling electric: 85.4 MWH/yr.
(0.042 MBtu/yr./sq.ft.)

Evaporative cooling electric: 25.2 MWH/yr.
(0.012 MBtu/yr./sq.ft.)

Lighting consumption electric: 217.1 MWH/yr.
(0.106 MBtu/yr./sq.ft.)

Process consumption electric: 203.1 MWH/yr.
(0.099 MBtu/yr./sq.ft.)

DHW consumption fuel (NG): 15.5 MBtu/yr., RUF
(0.0007 MBtu/yr./sq.ft.)

Misc. consumption electric: 0.3 MWH/yr.
(0.0002 MBtu/yr./sq.ft.)

Total fuel consumption (NG): 376.4 MBtu/yr., RUF
(0.016 MBtu/yr./sq.ft.)

Total electric consumption: 537.8 MWH/yr.
(0.263 MBtu/yr./sq.ft.)

Total energy consumption: 6,614.9 MBtu/yr., RUF
(0.278 MBtu/yr./sq.ft.)

4. Warehouses (440 00):

Building P01833, GEN PURP WHS (44220)
Gross area = 14,161 sq.ft.; Environmental area = 14,161 sq.ft.

Building P01833 is a good example of a typical WSMR warehouse. Relatively low energy consumption occurs in this type facility since storage is the basic purpose. They are typically evaporatively cooled and heated with unit gas heaters.

Energy Consumption:

Heating consumption fuel (NG):	382.2 MBtu/yr., RUF (0.027 MBtu/yr./sq.ft.)
Heating consumption electric:	0.60 MWH/yr. (0.0005 MBtu/yr./sq.ft.)
Evaportive cooling electric:	22.9 MWH/yr. (0.019 MBtu/yr./sq.ft.)
Lighting consumption electric:	27.4 MWH/yr. (0.022 MBtu/yr./sq.ft.)
Process consumption electric:	8.9 MWH/yr. (0.007 MBtu/yr./sq.ft.)
DHW consumption fuel (NG):	21.3 MBtu/yr., RUF (0.002 MBtu/yr./sq.ft.)
Misc. consumption electric:	1.0 MWH/yr. (0.0008 MBtu/yr./sq.ft.)
Total fuel consumption (NG):	403.5 MBtu/yr., RUF (0.028 MBtu/yr./sq.ft.)
Total electric consumption:	60.8 MWH/yr. (0.050 MBtu/yr./sq.ft.)
Total energy consumption:	1,108.8 MBtu/yr., RUF) (0.078 MBtu/yr./sq.ft.)

5. Medical Facilities (500 00):

Building P00530, HOSP CLINIC (51020)
Gross area = 51,948 sq.ft.; Environmental Area = 48,212 sq.ft.

Only two medical facilities were included in the Scope of Work for this study: building P00525, the Dental Clinic, and building P00530, the Hospital Clinic. The latter encompasses nearly 8 times the area of the Dental Clinic and consumes 20 times the amount of annual source energy. The Hospital Clinic has a large and complex array of mechanical systems (HVAC) whereas the Dental Clinic utilizes a much simpler multi-zone system. Both use refrigerated air conditioning and hot water heating exclusively. The data below pertains to building P00530.

Energy Consumption:

Heating consumption fuel (NG):	16,299.8 MBtu/yr., RUF (0.34 MBtu/yr./sq.ft.)
Heating consumption electric:	93.5 MWH/yr. (0.023 MBtu/yr./sq.ft.)
Regrigeration cooling electric:	333.9 MWH/yr. (0.08 MBtu/yr./sq.ft.)
Lighting consumption electric:	216.7 MWH/yr. (0.052 MBtu/yr./sq.ft.)
Process consumption electric:	239.9 MWH/yr. (0.058 MBtu/yr./sq.ft.)
DHW consumption fuel (NG):	1751.7 MBtu/yr., RUF (0.036 MBtu/yr./sq.ft.)
Misc. consumption electric:	15.6 MWH/yr. (0.004 MBtu/yr./sq.ft.)
Total fuel consumption:	18,050.8 MBtu/yr., RUF (0.37 MBtu/yr./sq.ft.)
Total electric consumption:	899.6 MWH/yr. (0.22 MBtu/yr./sq.ft.)
Total energy consumption:	28,486.2 MBtu/yr., RUF (0.59 MBtu/yr./sq.ft.)

6. Administrative (610 00):

Building P00102, FIN ADM BLDG (61027)
Gross area = 22,300 sq.ft.; Environmental area = 19,761 sq.ft.

Building P00102 is an average, although not typical, Administrative facility. It is hydronically heated and predominantly evaporatively cooled, although there is a relatively small refrigerated air conditioned zone. Several of the other Administrative buildings in this function category incorporate more sophisticated HVAC system components and different envelope construction and cannot therefore be considered as typical of the example building P00102.

Energy Consumption:

Heating consumption fuel (NG):	1,043.6 MBtu/yr., RUF (0.053 MBtu/yr./sq.ft.)
Heating consumption electric:	1.2 MWH/yr. (0.0007 MBtu/yr./sq.ft.)
Refrigeration cooling electric:	11.8 MWH/yr. (0.007 MBtu/yr./sq.ft.)
Evaporative cooling electric:	63.5 MWH/yr. (0.037 MBtu/yr./sq.ft.)
Lighting consumption electric:	93.0 MWH/yr. (0.055 MBtu/yr./sq.ft.)
Process consumption electric:	5.2 MWH/yr. (0.003 MBtu/yr./sq.ft.)
DHW consumption fuel (NG):	24.2 MBtu/yr., RUF (0.001 MBtu/yr./sq.ft.)
Misc. consumption electric:	5.9 MWH/yr. (0.003 MBtu/yr./sq.ft.)
Total fuel consumption:	1,067.8 MBtu/yr., RUF (0.054 MBtu/yr./sq.ft.)
Total electric consumption:	180.6 MWH/yr. (0.106 MBtu/yr./sq.ft.)
Total energy consumption:	3,162.7 MBtu/yr., RUF (0.160 MBtu/yr./sq.ft.)

7. Bachelor Housing (720 00):

Building P00126, EM BK W/O MS (72111)
Gross area = 54,818 sq.ft.; Environmental area = 51,632 sq.ft.

Building P00126 is an Enlisted Mens' Barracks (without mess service). It serves as a good representative of the bachelors quarters type facility since all have similar building envelopes and HVAC systems. These buildings are typically hydronically heated and evaporatively cooled. It should be noted that building P00160, function category 72210, the Enlisted Personnel Mess is atypical of the other buildings in the same category group. This eating facility consumes twice the average energy consumed by the barracks buildings.

Energy Consumption:

Heating consumption fuel (NG):	2,065.7 MBtu/yr., RUF (0.040 MBtu/yr./sq.ft.)
Heating consumption electric:	1.0 MWH/yr. (0.0002 MBtu/yr./sq.ft.)
Evaporative cooling electric:	164.7 MWH/yr. (0.037 MBtu/yr./sq.ft.)
Lighting consumption electric:	301.4 MWH/yr. (0.068 MBtu/yr./sq.ft.)
DHW consumption fuel (NG):	512.5 MBtu/yr., RUF (0.010 MBtu/yr./sq.ft.)
Misc. consumption electric:	46.7 MWH/yr. (0.010 MBtu/yr./sq.ft.)
Total fuel consumption:	2,578.2 MBtu/yr., RUF (0.050 MBtu/yr./sq.ft.)
Total electric consumption:	513.8 MWH/yr. (0.115 MBtu/yr./sq.ft.)
Total energy consumption:	8,538.3 MBtu/yr., RUF (0.165 MBtu/yr./sq.ft.)

8. Community Facilities (730 00 and 740 00):

Building P01330, OPEN MESS OFF (74048)
Gross area = 19,511 sq.ft.; Environmental area = 18,879 sq.ft.

Building P01330 is the Officers' Open Mess. This function category also has a number of buildings with atypical characteristics. This building is provided as an example building for this category group with the understanding that it cannot serve as a common, typical energy consuming Community Facility.

Energy Consumption:

Heating consumption fuel (NG):	394.8 MBtu/yr., RUF (0.021 MBtu/yr./sq.ft.)
Heating consumption electric:	19.9 MWH/yr. (0.012 MBtu/yr./sq.ft.)
Evaporative cooling electric:	28.8 MWH/yr. (0.018 MBtu/yr./sq.ft.)
Lighting consumption electric:	119.4 MWH/yr. (0.073 MBtu/yr./sq.ft.)
Process consumption fuel (NG):	124.8 MBtu/yr., RUF (0.073 MBtu/yr./sq.ft.)
Process consumption fuel (NG):	63.4 MWH/yr. (0.039 MBtu/yr./sq.ft.)
DHW consumption fuel (NG):	130.7 MBtu/yr., RUF (0.007 MBtu/yr./sq.ft.)
Misc. consumption electric:	52.5 MWH/yr. (0.032 MBtu/yr./sq.ft.)
Total fuel consumption (NG):	650.3 MBtu/yr., RUF (0.034 MBtu/yr./sq.ft.)
Total electric consumption:	284.0 MWH/yr. (0.175 MBtu/yr./sq.ft.)
Total energy consumption:	3,944.7 MBtu/yr., RUF (0.209 MBtu/yr./sq.ft.)

9. Family Housing (711 00):

Building P10932, (type "K"), FH CAPE NCO (71125)
Gross area = 1,502 sq.ft.; Environmental area = 1,432 sq.ft.

Housing type "K" is given as a representative example of a typical Family Housing residential structure. All houses are evaporatively cooled exclusively, although a very small number of units utilize refrigerated A/C window units also. Space heating is typically by forced air gas-fired furnaces with a few exceptions which use small boilers to supply baseboard heaters with hot water.

Energy Consumption:

Heating consumption fuel (NG):	79.6 MBtu/yr., RUF (0.056 MBtu/yr./sq.ft.)
Heating consumption electric:	0.4 MWH/yr. (0.0003 MBtu/yr./sq.ft.)
Evaporative cooling electric:	2.3 MWH/yr. (0.019 MBtu/yr./sq.ft.)
Lighting consumption electric:	2.3 MWH/yr. (0.019 MBtu/yr./sq.ft.)
Process consumption fuel (NG): (Cooking)	10.5 MBtu/yr., RUF (0.007 MBtu/yr./sq.ft.)
DHW consumption fuel (NG):	20.8 MBtu/yr., RUF (0.015 MBtu/yr./sq.ft.)
Misc. consumption electric:	3.2 MWH/yr. (0.026 MBtu/yr./sq.ft.)
Total fuel consumption:	110.9 MBtu/yr., RUF (0.077 MBtu/yr./sq.ft.)
Total electric consumption:	8.2 MWH/yr. (0.066 MBtu/yr./sq.ft.)
Total energy consumption:	206.0 MBtu/yr., RUF (0.144 MBtu/yr./sq.ft.)

ENERGY CONSERVATION OPPORTUNITIES DEVELOPED

Once the data collection phase of the work was completed and all data bases assembled, Energy Conservation Opportunities (ECO's) were identified and specific applications investigated. The following is the original list of ECO's as compiled by Southwestern Energy Group to be included for analysis under Increments A, B or G. This list can also be found in Section 4.3.2, Volume 1 of this Report, beginning on Page 4-2.

ECO's INVESTIGATED

Increment A

Group A - Building Envelope ECO's

A-1 Roof Insulation
A-2 Wall Insulation
A-3 Storm Windows or Double Glazing
A-4 Weatherstripping, Caulking and Automatic Closers on Exterior Doors and Windows
A-5 Solar Reflective Film
A-6 Vestibules
A-7 Insulation Between Conditioned and Non-Conditioned Spaces

Group B - Lighting Systems ECO's

B-1 Energy Conserving Fluorescent Lamps and Ballasts
B-2 Change to Most Efficient Light Source (Interior) (See ECO B-1)
B-3 Change to Most Efficient Light Source (Exterior)
B-4 Reduction of Light Levels with Accessory Units (See ECO B-1)
B-5 Switches and Timers (Interior Lighting)
B-6 Photocells and Timers (Exterior Lighting
B-7 Keep Lamp Surfaces Clean

Group C - HVAC Systems ECO's

C-1 Automatic Reset Thermostats
C-2 Infrared Heaters
C-3 Economizer Cycles (using outside air for cooling)
C-4 Insulate Steam and Hot Water Lines (see ECO H-2)
C-5 Flue Gas Analyzers with Feedback Trim
C-6 Thermostatically Controlled Boiler Staging (See ECO C-5 and C-37)
C-7 Time Clocks for Boiler Cycling (See ECO C-6)
C-8 Heat Exchangers Between Exhaust and Fresh Air Intake
C-9 Reduce Leakage of Outside Air Dampers (see ECO H-3)
C-10 Boiler Oxygen Trim Control (combustion controls) (see ECO C-5)
C-11 Boiler Control (improve burner efficiencies) (see ECO C-5)

C-12 Chiller Controls and Staging (See ECO C-6)
C-13 Replace Obsolete Chillers
C-14 Replace Absorption Chillers
C-15 Insulation of Return Condensate Lines and Tank (see ECO H-2)
C-16 Air Washers
C-17 Thermostatic Controls for Air Washer Pumps
C-18 VAV Controls for Air Washers (and 2 speed motors)
C-19 Evaporative Cooler Motors
C-20 Turbulators in Fire Tube Boilers
C-21 Auto-ignition/Vent Dampers on Gas Heaters
C-22 Reduce Outside Make-up Air
C-23 Reduce or Eliminate Ventilation During Unoccupied Periods
C-24 Insulation of Chilled Waterpiping and Ductwork in Non-Conditioned Spaces (see ECO H-2)
C-25 Eliminate Simultaneous Heating and Cooling
C-26 Convert Constant Volume Systems to VAV Systems
C-27 Replace Inefficient Window Air Conditioners
C-28 Clean Return Air and Reduce Need for Outside Air
C-29 Chilled Water Storage (and hot water storage)
C-30 Strainer Cycle for Chilled Water
C-31 Two-Stage Evaporative Cooling
C-32 Reverse Flow Evaporative Water Chillers
C-33 Preheat Combustion Air
C-34 Hot Deck and Cold Deck Temperature Reset
C-35 Add Evaporative Cooling to HVAC Systems
C-36 All Hydronic Heating and Cooling
C-37 Central Piping Loop
C-38 Install Liquid-Type Heat Extractors on all Furnaces and Boiler Flues

Group D - Ancillary Systems ECO's

D-1 Domestic Hot Water Circulation Pump Controls
D-2 Decentralize Domestic Water Heaters
D-3 Flue Gas Heat Recovery in Boilers (See ECO C-33)
D-4 Superimposed Second Roofs
D-5 Exhaust Evaporative Cooler Air through Attic
D-6 Translucent Insulation Type Dropped Ceilings
D-7 Recover Waste Heat from Chillers for Heating Buildings
D-8 Replace Chilled Air Systems with Chilled Water Systems (See ECO C-36)

Group E - Family Housing ECO's

E-1 Shower Flow Restrictors
E-2 Water Heater Insulation Jackets
E-3 Fluorescent Lighting
E-4 Roof Insulation
E-5 Storm Windows or Double Glazing
E-6 Weatherstripping and Caulking
E-7 Wall Insulation
E-8 Exhaust Evaporative Cooled Air through Attic
E-9 Automatic Set-back Thermostats
E-10 Two-speed Evaporative Cooler Motors

E-11 Solar Reflective Films
E-12 Solar Heating through Attic
E-13 Install Liquid-Type Heat Extractors on all Furnace and Boiler Flues

Group F - Special Consideration ECO's

F-1 FM Radio Controls
F-2 Heating Reclaimed from Hot Refrigerant Gas
F-3 Blow Down Heat Recovery
F-4 Reduce Volume of Heating/Cooling Bays
F-5 Isolation of Inactive Areas of Buildings
F-6 Shower Flow Restrictors
F-7 Office Area Ceiling Insulation

Increment B

Group G - Utilities and Energy Distribution Systems ECO's

G-1 Outdoor Lights
G-2 Water Pumps and Motors

Increment G

Group H - Operations and Maintenance ECO's

H-1 Radiator Valves
H-2 Repair Insulation
H-3 Reduce Leakage of Outside Air Dampers

Overview of ECO Analyses

The Energy Conservation Opportunities (ECO's), as presented in Volume I, Section 4 of this report, were evaluated individually on a stand-alone basis and prioritized according to their respective energy-to-cost (E/C) ratios. ECO's which satisfied minimum E/C ratio criteria (E/C $\geq$ 13) were then considered for potential inclusion in Energy Conservation Investment Program (ECIP) projects. Many ECO's were found to be non-viable based on their economic analyses and others were determined to be ineligible for inclusion in ECIP projects because they did not conform with Army regulations. Still, others were found to be duplicated by other ECO's or simply not applicable to the WSMR complex. The following discussion documents the ultimate status of all ECOs which were originally selected to be analyzed.

ECO's Not Allowed by Army Regulations

Three ECO's were found to be in conflict with Army regulations and were therefore eliminated from further consideration:

- ECO A-5 Solar Reflective Film
  Not allowed by Army regulations when field applied.
- ECO C-16 Air Washers
  Slinger are not allowed by Army regulations.
- ECO E-11 Solar Reflective Films (Family Housing)
  Not allowed by Army regulations when field applied.

ECO's Duplicated By or Included in Other ECO's

Fourteen ECO's were duplicated by or included in other ECO's and were not analyzed under their original ECO number. These included:

- ECO C-4 Insulate Steam and Hot Water Lines
  Included with ECO H-2.
- ECO C-6 Thermostatically Controlled Boiler Staging
  Included with EMCS analysis.
- ECO C-7 Time Clocks for Boiler Cycling
  Included with EMCS analysis.
- ECO C-9 Reduce Leakage of Outside Air Dampers
  Accomplished in ECO C-23.
- ECO C-10 Boiler Oxygen Trim Control
  Included with ECO C-5.
- ECO C-11 Boiler Control
  Included with ECO C-5.
- ECO C-12 Chiller Controls and Staging
  Included with EMCS analysis.

- o ECO C-15 Insulation of Return Condensate Lines and Tank
  Included with ECO H-2.

- o ECO C-24 Insulation of Chilled Water Piping and Ductwork in Non-conditioned Spaces
  Included with ECO H-2.

- o ECO D-1 DHW Circulation Pump Controls
  Included with EMCS analysis.

- o ECO D-3 Flue Gas Heat Recovery in Boilers
  Included with ECO C-33.

- o ECO D-8 Replace Chilled Air Systems With Chilled Water Systems
  Accomplished in ECO C-36.

- o ECO F-1 FM Radio Controls
  Included with EMCS analysis.

- o ECO H-3 Reduce Leakage of Outside Air Dampers
  Accomplished in ECO C-23.

ECO's Determined Not Applicable to WSMR

Fifteen ECO's were determined to be non-applicable to the WSMR base due to various reasons as given below:

- o ECO B-5 Switches and Timers (Interior Lighting)
  This has already been implemented at WSMR and is considered adequate at this time.

- o ECO B-6 Photocells and Timers (Exterior Lighting)
  Same as ECO B-5 above.

- o ECO C-14 Replace Absorption Chillers
  Only one absorption chiller is believed to be in operation at WSMR (building P01534) and there is a current funded project underway to replace this unit with an electrically driven chiller.

- o ECO C-22 Reduce Outside Make Up Air
  FE personnel have already taken measures to insure that fresh air intakes do not exceed minimum requirements set forth by ASHRAE standards.

- o ECO C-29 Chilled Water Storage and/or Hot Water Storage
  Not effective enough to implement.

- o ECO C-32 Reverse-Flow Evaporative Water Chillers
  This product is not yet available on the commercial market.

- o ECO D-2 Decentralize Domestic Water Heaters
  It was determined that this application was not suitable for the WSMR complex since most DHW units are already of

a fairly efficient size and only a few instances were found to use central (district) DHW systems.

- ECO E-1 Shower Flow Restrictors (Family Housing)
  A currently funded ECIP project by others is now underway at WSMR to accomplish this ECO.

- ECO E-3 Fluorescent Lighting (Family Housing)
  A currently funded ECIP project by others is now underway at WSMR to accomplish this ECO.

- ECO E-9 Automatic Setback Thermostats (Family Housing)
  A currently funded ECIP project by others is now underway at WSMR to accomplish this ECO.

- ECO E-12 Solar Heating Through Attic (Family Housing)
  Impractical, non-applicable.

- ECO F-5 Isolation of Inactive Areas of Buildings
  No substantial applications for this ECO were discovered during the study.

- ECO F-7 Office-area Ceiling Insulation
  Few applications were found and it was determined that ECO A-1 would cover the work set forth by this project.

- ECO G-1 Outdoor Lights
  This project is already underway at WSMR throughout the base and no further actions are deemed necessary at this time.

- ECO H-1 Radiator Valves
  No applications were discovered during the audit phase and therefore, no action is required.

ECO's Which Fail to Meet ECIP Criteria

Twelve of the original ECO's were analyzed and determined to be non-viable based on their economic analyses. These are listed below along with E/C ratios:

- ECO A-7 Insulation Between Conditioned and Non-conditioned Spaces
  (E/C = 1.6)

- ECO B-3 Change to Most Efficient Light Source (Exterior)
  (E/C = 3.5)

- ECO C-2 Infrared Heaters
  (E/C = 11.1)

- ECO C-5 Flue Gas Analyzers with Feedback Trim
  (E/C = 9.1)

- o ECO C-8 Heat Exchangers Between Exhaust and Fresh Air Intake (E/C = 10.3)
- o ECO C-17 Thermostatic Controls for Air Washer Pumps (E/C = 3.7)
- o ECO C-27 Replace Inefficient Window Air Conditioners (E/C = 5.6)
- o ECO C-37 Central Piping Loop (E/C = 12.2)
- o ECO D-4 Superimposed Second Roofs (E/C = 11.0)
- o ECO D-6 Translucent Insulation Type Dropped Ceilings (E/C = 4.4)
- o ECO E-4 Roof Insulation (Family Housing) (non-viable, physically infeasible)
- o ECO F-4 Reduce Volume of Heating/Cooling Bays (E/C = 4.7)

Viable ECO's with ECIP Potential

Forty one ECO's analyzed under Increments A and B were determined to be viable based on the E/C ratio 13.0. These ECO's are listed below in a prioritized sequence beginning with the highest E/C ratio. Refer to individual ECO analyses in Section 4 of Volume I for details.

Ranking	ECO #	E/C (MBtu/yr.)	Energy Savings (MBtu/yr.)	Comment	FY85 Cost (K$)
1	B-7	3,182.0	3,392	Incr. F	1.066
2	C-1	693.3	8,369		12.07
3	A-4	386.0	10,077.0	Incr. F	26.1
4	C-3	366.2	4,808		13.1
5	C-20	330.8	2,789		8.43
6	E-2	144.9	3,008.6		20.8
7	H-2	126.1	996.2	Incr. F	7.89
8	D-7	117.0	9,416		80.5
9	C-30	114.6	13,451.4		117.9
10	C-34	104.4	1,069		10.24
11	F-6	88.8	310.9	Incr. F	3.5
12	F-3	86.6	1,753		20.24
13	C-35	82.4	8,680.3		168.4
14	F-2	66.0	1,159.8		17.56
15	C-33	60.3	703		11.67
16	E-7	57.8	18,915		327.4
17	A-6	56.5	80.22	Incr. F	1.42
18	C-19	53.9	14,039		260.2
19	A-1	52.0	1,955.2		37.6
20	C-26	50.3	13,044		259.17
21	E-6	48.9	3,322.8		67.9

Ranking	ECO #	E/C (MBtu/yr.)	Energy Savings (MBtu/yr.)	Comment	FY85 Cost (K$)
22	E-10	48.0	9,235.9		192.4
23	C-36	41.0	78,885.6		1,924.4
24	C-38	35.9	22,504		526.4
25	B-1, & (B-2, B-4)	34.9	53,720		1,536.1
26	C-13	32.4	44,358		1,368.0
27	D-5	32.3	1,416.4		43.8
28	E-5	30.7	10,583.7		344.6
29	C-21	26.3	3,140		119.37
30	C-28	25.5	940.1		36.86
31	A-3	25.4	5,937.1		234.0
32	C-23	25.3	2,499		98.85
33	G-2	22.6	3,010		133.12
34	A-2	22.2	11,066.9		496.8
35	C-18	21.8	3,354		154.2
36	E-8	18.6	6,539.9		351.4
37	E-13	18.5	13,441		725.3
38	C-31	13.3	522		39.2
39	C-25	12.8	1,378		108.08

ECIP PROJECTS DEVELOPED UNDER INCREMENTS A, B and G

Prior to Contract Modification P00003, which incorporated 22 September 1982 Scope of Work, ECIP criteria was based on a minimum Energy-to-Cost (E/C) ratio of 13, and a minimum capital investment of $100,000 (FY85 CWE). Contract Modification P00003 revised that criteria to require that ECIP projects be evaluated using a different life cycle cost analysis methodology, the Savings-to-Investment Ratio (SIR). This analysis was to be accomplished using the SIR computer program as provided by the Fort Worth District Corps of Engineers. Under this new criteria all ECIP projects must meet or exceed the minimum SIR value of 1.0 in order to qualify for funding through government channels. The revised Scope (P0003) later included an additional modification which changed the former minimum expenditure for ECIP projects which was $100,000 (Current Working Estimate) to $200,000. Thirteen ECIP projects which were originally designed for the Pre-Final submittal of this report were revised accordingly to incorporate this minimum $200,000 expenditure. The result was a reduction in the number of Increment A and B projects from thirteen to nine.

The nine ECIP projects generated from the Energy Conservation Opportunity (ECO) studies evaluated under Increments A, B and G are listed below in descending order according to their respective SIR values.

Increment A and B ECIP Projects:

(1) Title: Variable Air Volume ECIP

Temporary project number: T-02300

Description: This project will replace old and inefficient electric motors in existing evaporative coolers and/or air washers

with new high efficiency thermostatically controlled two-speed electric motors. Buildings with air-conditioning systems other than the evaporative type will have existing constant volume fan motors replaced with new high efficiency thermostatically controlled variable speed electric motors. The conversion from constant volume to variable air volume (VAV) will result in a reduction in electrical energy consumption as it allows fan energy to be reduced during periods when peak cooling is not required (as ambient conditions allow). A total of 63 existing WSMR Buildings will be affected by these actions.

Energy Savings[1]:

electric:	862.4	MWH/year
natural gas:	5018	MBtu/year
total:	15,022	MBtu/year
FY85 CWE:	$301,000	
First Year Dollar Savings[2]:	$79,650	
SIR:	3.91	
Amortization:	2.91	years

(2) Title: Family Housing ECIP for Envelope Improvement and Evaporative Cooler Exchange

Temporary project number: T-02700

Description: New weatherstripping will be installed along all window and exterior door cracks in 823 existing WSMR family housing structures (885 living units). In certain residences with uninsulated frame walls, cellulose fiber insulation will be blown into the empty wall cavities between studs to reduce heat transmission rates. In addition to the above, all 885 living units will have existing evaporative cooler motors replaced with high efficiency thermostatically controlled two-speed electric motors.

Energy savings:

electric:	1072.2	MWH/year
natural gas:	20,405	MBtu/year
total:	32,843	MBtu/year
FY85 CWE:	$576,000	
First Year Dollar Savings:	$159,235	
SIR:	3.9	
Amortization:	3.0	years

[1] All energy savings in MBtu/yr are in millions of BTU of source energy.

[2] First Year Dollar Savings derived from SIR program output using FY83 Energy Costs of $5.83/MBtu for electricity, $4.25/MBtu for natural gas and $6.70/MBtu for propane.

(3) Title: HVAC System Modifications ECIP

Temporary project number: T-02400

Description: This project involves numerous mechanical systems alterations/additions which will result in substantial energy savings in 68 existing WSMR structures. The work to be accomplished includes the following:

1. The installation of automatic reset thermostats to set up temperatures at night in refrigerated areas in summer and to set down the temperature setpoint at heated areas at night (winter).

2. Auto Ignition/Vent Dampers to shut off pilot lights and to reduce the amount of infiltration through heater stacks during off cycles.

3. Existing water pump motors at the central pump house and existing well pump stations will be replaced with energy efficient motors.

4. Energy will be reclaimed from the hot refrigerant gas at refrigerant systems and used to heat domestic hot water systems.

5. Boiler blowdown currently is not automatic. Addition of automatic blowdown with heat recovery will allow the recovery of heat currently wasted during blowdown.

6. Installation of a boiler stack economizer coil and associated runaround coil with fans to overcome added static resistances.

In addition to the above actions, building P00530, the Hospital Clinic, will receive special attention to reduce its present enormous energy consumption. This building will benefit from the following actions:

1. The installation of an enthalpy economizer to modify the existing dry bulb type economizer.

2. The installation of a variable volume system to replace existng constant volume systems at the administrative spaces.

3. The reduction of existing ventilation rates at non-medical spaces.

4. Reset of hot and cold deck temperatures to allow reheat systems to operate more economically from the requirements of the worst zone.

5. Energy will be reclaimed from blowdown steam by heat exchange devices and transferred to feed water.

Energy savings:

electric:	586.4	MWH/year
natural gas:	18,131	MBtu/year
total:	24,933	MBtu/year

FY85 CWE:	$423,000
First Year Dollar Savings:	$116,712
SIR:	3.84
Amortization:	3.14 years

(4) Title: ECIP to Change to Most Efficient Light Source

Temporary project number: T-02500

Description: This project will change out existing fluorescent core ballasts with new high frequency semiconductor ballasts. Existing incandescent lamps will be replaced with folding fluorescent tubes and semiconductor ballasts with screw in bases. Where applicable, photosensitive lighting controls will be installed to maximize potential use of natural daylighting and reduce electric lighting loads at perimeter zones which have windows. A total of 156 existing WSMR bulidings are recommended for inclusion in this project. If implemented, a substantial portion of the electrical consumption at WSMR will be reduced.

Energy savings:

electric:	5505.4	MWH/year
natural gas:	(-7811)	MBtu/year
propane (LPG)	(-233)	MBtu/year
total:	55,819	MBtu/year

FY85 CWE:	$1,458,000
First Year Dollar Savings:	$337,563
SIR:	2.92
Amortization	3.70 years

(5) Title: Replace Chillers and Add Strainer Cycle

Temporary project number: T-02600

Description: This project will replace certain obsolete chiller systems used for space and equipment cooling with new high efficiency chillers of the water cooled condenser type. New energy efficient cooling towers will also be provided as required. The total requirement is 2725 tons of chiller equipment with units ranging from 5 to 165 tons at the various buildings. Twenty existing WSMR facilities will be affected by these actions. Also, pumps, control valves, filters and related accessory equipment is to be installed as required to provide free cycle cooling by bypassing condensers with chilled water from cooling towers which, when ambient conditions

allow, can be pumped directly to air handlers for cooling. This technique is known as the strainer cycle and can be effectively used to reduce air-conditioning energy consumption in temperate climates. A total of 22 existing facilities are included in this project.

Energy savings:

Electric:	4216.6	MWH/year
Total:	48,912	MBtu/year

FY85 CWE:	$1,615,000	
First Year Dollar Savings:	$285,157	
SIR:	2.75	
Amortization:	4.86	years

(6) Title: Family Housing ECIP DHW Insulation and Storm Windows

Temporary project number: T-03100

Description: Eight hundred eighty five existing domestic water heater tanks will be fitted with new insulation jackets to reduce stand-by conduction heat losses. Four hundred sixty of the capehart family houses will be retrofitted with new secondary glazings to reduce heat losses through window areas. (The other 425 family units are currently being retrofitted with storm windows through another project.)

Energy savings:

electric:	123.4	MWH/year
natural gas:	12,161	MBtu/year
total:	13,593	MBtu/year

FY85 CWE:	$361,000	
First Year Dollar Savings:	$60,033	
SIR:	2.39	
Amortization:	5.16	years

(7) Title: ECIP to Install Liquid Type Heat Extractors on all Furnace and Boiler Flues

Temporary project number: T-02800

Description: This project will install liquid type heat recovery devices and accessory equipment such as heat exchangers, pumps, etc. on all gas fired furnace and boiler flues of 106 existing WSMR buildings. The reclaimed heat will be distributed to areas which can use the heat for space heating and/or to domestic water heater units for preheating supply water.

Energy savings:

natural gas:	19,941	MBtu/year
propane: (LPG):	1,790	MBtu/year
total:	21,731	MBtu/year

FY85 CWE:	$768,000
First Year Dollar Savings:	$96,742
SIR:	1.84
Amortization:	6.8 years

(8) Title: ECIP to Install Roof and Wall Insulation

Temporary project number: T-02900

Description: This project will upgrade the thermal envelopes of 28 existing WSMR structures by providing additional roof and/or wall insulation as required. R-19 batt insulation will be added to the existing ceiling-roof cavities of 4 buildings and R-11 wall insulation will be added to the inside face of existing walls (with new furred-out gypsum board) of 27 buildings. Three of the above mentioned buildings are to receive both roof and wall insulation. A total of 28 existing buildings are included in this project. Energy savings will be realized through a reduction in HVAC equipment consumption.

Energy savings:

electric:	180.3 MWH/year
natural gas:	8711 MBtu/year
propane (LPG):	2185 MBtu/year
total:	12,987 MBtu/year

FY85 CWE:	$527,000
First Year Dollar Savings:	$63,852
SIR:	1.72
Amortization:	7.09 years

(9) Title: ECIP to Install Storm Windows

Temporary project number: T-03000

Description: This project will install new secondary glazing panels to the existing windows of 24 WSMR Buildings. Energy savings will be realized through a reduction in HVAC equipment energy consumption.

Energy savings:

electric:	18.8 MWH/year
natural gas:	5719 MBtu/year
total:	5937 MBtu/year

FY85 CWE:	$231,000
First Year Dollar Savings:	$25,577
SIR:	1.61
Amortization	7.72 years

In addition to the 9 ECIP projects generated from Increments A and B, one other project, which failed to meet life-cycle-cost criteria (SIR $>$ 1.0) based on its SIR value of 0.30, is recommended

for further consideration under Increment G due to its high energy savings potential. This project is described below.

(10) Title: EMCS/Central Piping Loop

Temporary project number: T-03200

Description: This project will install an Energy Monitoring and Control System at the base and a central piping loop for chilled and hot water distribution.

Energy savings:

electric:	2973.1 MWH/year
natural gas:	55,012 MBtu/year
total:	89,500 MBtu/year

FY85 CWE:	$10,668,000
First Year Dollar Savings:	$177,026
SIR:	0.30
Amortization:	(none)

The following figures are provided to summarize the material presented in section 4.5.

Increment A and B ECIP projects (#1 - #9):

Total energy savings:	231,777.3 MBtu/year
Total FY85 capital investment:	$6,260,000
Total First Year Dollar Savings:	$1,224,521

Increment G ECIP (#10):

Energy savings:	89,500 MBtu/year
FY 85 capital investment:	$10,668,000
First Year Dollar Savings:	$177,026

OTHER ENERGY CONSERVATION PROJECTS

Five of the ECO's which were originally evaluated under Increment A proved to be economically viable based on E/C ratio criteria but did not meet the minimum FY85 capital expenditure limit of $200,000. These are low cost projects which could easily be accomplished by maintenance personnel and are therefore recommended for inclusion under Increment F. Since the submittal of the Pre-Final Report these five projects were reevaluated under modified Scope criteria which requires that life cycle cost analyses be performed using the Savings Investment Ratio (SIR) computer analysis program. Note that these projects also required cost estimates to be updated to incorporate the latest escalation factors (EIRS-82-02) and the change of SIOH (Supervision Inspection and OverHead) from 5% to 5.5%. The changes account for the differences in FY85 CWE (Current Working Estimate) values shown below and those given in the original ECO presentations in Section 4 of Volume I of the Final Report. A summary of the five additional projects recommended for inclusion under Increment F is given below. Refer to original ECO presentations as given in Section 4, Volume I for detailed descriptions of these projects.

(1) ECO B-7 Keep Lamp Surfaces Clean

Energy Savings:

electric:	292.4	MWH/year
total:	3392	MBtu/year
FY85 CWE:	*$1,200	
First Year Dollar Savings:	$18,825	
SIR:	24.18	
Amortization:	0.7	years

* A recurring increase in annual labor expenses only (no other capital investment is required).

(2) ECO A-4 Weatherstripping and Caulking

Energy Savings

electric:	268.8	MWH/year
natural gas:	6130.3	MBtu/year
propane (LPG):	819.5	MBtu/year
total:	10,067.6	MBtu/year
FY85 CWE:	$23,460	
First Year Dollar Savings:	$49,721	
SIR:	26.61	
Amortization:	0.45	years

(3) ECO H-2 Repair Insulation

Energy Savings:

electric:	4.15	MWH/year
natural gas:	921.7	MBtu/year
propane (LPG):	26.4	MBtu/year
total:	996.2	MBtu/year
FY85 CWE:	$8,770	
First Year Dollar Savings:	$4,375	
SIR:	7.22	
Amortization:	1.72	years

(4) ECO F-6 Shower Flow Restrictors

Energy Savings:

natural gas:	310.9	MBtu/year
total:	310.9	MBtu/year
FY85 CWE:	$3,460	
First Year Dollar Savings:	$1,321	
SIR:	5.57	
Amortization:	2.25	years

(5) ECO A-6 Vestibules

Energy Savings:

electric:	0.034	MWH/year
natural gas:	79.8	MBtu/year
total:	80.2	MBtu/year
FY85 CWE:	$1,400	
First Year Dollar Savings:	$341	
SIR:	3.56	
Amortization:	3.52	years

These five projects will result in the following overall savings if implemented:

Annual Energy Savings:

electric:	565.3	MWH/year
natural gas:	7,442.7	MBtu/year
propane (LPG):	845.9	MBtu/year
total:	14,846.9	MBtu/year
Total FY85 CWE:	$38,290	
Total First Year Dollar Savings:	$74,583	

These projects are recommended for implementation under Increment F.

Other than the five projects described in the preceding paragraphs and the 10 ECIP projects generated from Increments A, B and G, there are no other energy conservation projects proposed for development under Increments A, B or G at this time. Increment C (Geothermal and Solar) studies revealed that the current and near future projected costs of utilities energy at WSMR are not high enough to make geothermal or solar related projects economically viable under ECIP criteria.

Increment F (low to no cost maintenance and repair) studies resulted in several additional viable projects. These projects are described in detail in Volume III of this Final Report and are summarized in the Executive Summary under Increment F. Also included in the synopsis of Increment F is a complete assessment of all incremental projects developed during this study which are proposed for implementation.

POLICY CHANGES AND RECOMMENDATIONS

Current efforts on behalf of the WSMR FE and Master Planning offices to reduce existing energy consumption are considered to be adequate and no policy changes are deemed necessary. The 19 Increment A and B ECIP projects are recommended for implementation as they will result in substantial energy and dollar savings. Increment F projects are also recommended for implementation.

At this time, the EMCS project, in conjunction with the proposed Central Piping Loop, is not recommended for implementation since no payback is expected. As energy costs continue to rise, this project may require reconsideration since it affords attractive energy savings potential, but, in light of the capital expenditure required to accomplish this project, it is not currently proposed for consideration. A summary of total energy and dollar savings for all projects recommended is given in Increment F of this Executive Summary.

ENERGY AND COST SAVINGS

The following presents projections of overall energy and cost savings anticipated to result from the implementation of the ECIP projects developed under Increments A and B and those projects developed under Increment F. Increment C resulted in no project recommendations and, as aforementioned, the EMCS/Central Piping Loop ECIP from Increment G is not recommended for implementation at this time.

- Energy Savings: Total source (RUF) energy savings projected by FY 1985:

Increment A & B projects:	231,777.3 MBtu/yr.
Increment F projects:	2,478.4 MBtu/yr.
Increment F (fallout from A & B):	14,846.9 MBtu/yr.
FY 1985 Total:	249,102.6 MBtu/yr.

- Energy Cost Savings: Total dollar savings projected by FY 1985:

Increment A & B projects:	$1,224,521.00
Increment F projects:	$ 11,560.00
Increment F (fallout from A & B)	$ 74,583.00
FY 1985 Total:	$1,310,664.00

BASE-WIDE ENERGY CONSUMPTION AFTER ENERGY CONSERVATION PROJECTS

Assuming that all 9 of the proposed Increment A and B ECIP projects and the Increment F projects are implemented, the source energy consumption projected for FY85 can be estimated as follows:

FY 1985 total non-vehicular source energy consumption:

1,163,667	MBtu/yr.	
- 249,103	MBtu/yr.	(less projected savings)
914,564	MBtu/yr.	

FY 1985 projected total source energy consumption:

914,564 MBtu/yr.

Using FY 1975 as a baseline year for evaluating energy consumption reduction goals, the energy conservation actions recommended, if implemented, will result in the following estimated percentage of consumption reduction:

$$\frac{(1,279,989 - 914,564)}{1,279,989} \times 100 = 28.55\%$$

This reduction easily exceeds the primary goal of achieving a 20 percent reduction of source energy consumption by FY 1985 as set forth by the Army Facilities Energy Plan.

A secondary goal of achieving a 40 percent reduction of energy consumption by FY 2000 will require additional action. Assuming that, at some time in the future, WSMR Master Planners elect to implement the EMCS/Central Piping Loop ECIP as an Increment G project, this goal can also be met with some supplementary actions to provide the additional energy savings required. If this project is implemented, annual source energy consumption would be reduced to:

(914,564 - 89,500) MBtu/yr. = 825,064 MBtu/yr.

This reduction in annual consumption would result in the following percentage of energy reduction based on FY 1975:

$$\frac{(1,279,989 - 825,064)}{1,279,989} \times 100 = 35.54\%$$

which almost meets long range goals for FY 2000.

PROJECTED ENERGY CONSUMPTION

Based on the assumption that all 9 of the proposed ECIP projects and the Increment F projects (including 5 fallout projects from Increment A) are implemented prior to FY 1985, the following projections for annual source energy consumption are anticipated.

Annual Source Energy Consumption:

	(FY 1975)	(FY 1985)	Percent Reduction
Electricity:	71,863,022 kWh 833,611 MBtu	57,318,519 kWh 664,895 MBtu	20.24%
Natural Gas:	3,907,980 Therms 390,798 MBtu	1,901,120 Therms 190,112 MBtu	51.35%
Propane:	581,990 gal. 55,580 MBtu	396,408 gal. 37,857 MBtu	31.89%
Grand Total:	1,279,989 MBtu	914,564 MBtu*	28.55%

*Includes 21,692 MBtu of Non-accountable energy to remain consistent with FY81 data used for projecting FY85 consumption. See page ES-4.

PROJECTED ENERGY COSTS

Energy costs were obtained during Phase I of the study and escalated to FY85 using long term escalation rates provided by "ECIP Guidance". Electricity was escalated using 13% per year and natural gas and propane were escalated using 14% per year. These costs were escalated using the following methodology.

Cost for each energy type were obtained from WSMR FE records using the most current prices which at the time was in mid-FY 1981. These costs were averaged from utilities records provided by the FE office.

1. Electricity data was taken from utility bills from the El Paso Electric Company and from consumption/cost data collected by WSMR FE personnel. The calculations which follow were based on metering at the Post area, AMRAD, MAR and ALA-5.

   Site (RIF): average mid-FY 1981 cost = $0.0510/kWh

   Source (RUF): $\frac{\$0.051}{\text{kWh}} \times \frac{1}{11{,}600} \frac{\text{kWh}}{\text{Btu}} \times \frac{1{,}000{,}000}{1} \frac{\text{Btu}}{\text{MBtu}} = \frac{\$4.40}{\text{MBtu}}$

   Escalate from mid-FY 1981 to BOD, end of FY 1985:

   Site: $\$0.051/\text{kWh} \times (1.13)^{4.5} = \$0.088/\text{kWh (site)}$

   Source: $\$4.40/\text{MBtu} \times (1.13)^{4.5} = \$7.62/\text{MBtu (RUF)}$

2. Natural Gas data was compiled from utility bills from the Gas Company of New Mexico and from consumption/cost data collected by WSMR FE personnel.

   Site (RIF): average mid-FY 1981 cost = $0.2754/therm

   Source (RUF): $\frac{\$0.2754}{\text{therm}} \times \frac{1 \text{ therm}}{100{,}000 \text{ Btu}} \times \frac{1{,}000{,}000 \text{ Btu}}{1 \text{ MBtu}} \times 0.97 = \frac{\$2.67}{\text{MBtu}}$

   Escalate from mid-FY 1981 to BOD, end of FY 1985:

   Site: $\$0.2754/\text{therm} \times (1.14)^{4.5} = \$0.4966/\text{therm (site)}$

   Source: $\$2.67/\text{MBtu} \times (1.14)^{4.5} = \$4.82/\text{MBtu (RUF)}$

3. Propane (LPG) data was obtained directly from WSMR FE records of consumption and cost.

   Site (RIF): average mid-FY 1981 cost = $0.604/gallon

   Source (RUF): $\frac{\$0.604}{\text{gallon}} \times \frac{1 \text{ gallon}}{95{,}500 \text{ Btu}} \times \frac{1{,}000{,}000 \text{ Btu}}{1 \text{ MBtu}} = \frac{\$6.32}{\text{MBtu}}$

   Escalate from mid-FY 1981 to BOD, end of FY 1985:

   Site: $\$0.604/\text{gallon} \times (1.14)^{4.5} = \$1.09/\text{gallon (site)}$

   Source: $\$6.32/\text{MBtu} \times (1.14)^{4.5} = \$11.40/\text{MBtu (RUF)}$

Using the above calculated values for FY 1985 energy costs and the projected FY 1985 energy consumption as previously derived, we can estimate the total cost of electrical, natural gas and propane energy for that fiscal year.

Electricity

Site cost: 57,318,519 kWh x $0.088/kWh = $5,044,030

Natural Gas

Site cost: 1,901,120 therms x $0.4966/therm = $944,096

Propane (LPG)

Site cost: 396,408 gallons x $1.09/gallon = $432,085

Total non-vehicular energy cost = $6,420,211

INCREMENT C OVERVIEW

This Increment C will determine the feasibility of utilizing renewable energy resources as a replacement for non-renewable energy sources.

SCOPE

Increment C (Geothermal and Solar only) involves renewable energy projects. Although not strictly a renewable energy source, Geothermal is to be considered among the alternatives. The projects developed under this increment will determine the feasibility of utilizing Solar and Geothermal for space heating, space cooling, domestic hot water or process heat, or combinations thereof.

The work to be accomplished is divided into three phases. They are:

Phase I	-	Data gathering and field trips.
Phase II		Analysis of data, identification of projects, evaluation of technical and economic feasibility.
Phase III	-	Preparation of reports and project documentation.

PROCEDURES

The study presents the evaluation, methodology, and economic analysis for solar energy applications and photo-voltaic systems. Solar systems are investigated for the purposes of domestic hot water generation, space cooling, space heating, and process hot water heating.

The study of geothermal energy includes a description of the geothermal resource potential, the methods of development and utilization of the resource, distribution, and effluent disposal techniques. Also included are the evaluation methodology and technical and economic analysis as well as the institutional and legal concerns for geothermal development.

Survey of potential usage of the systems has been made in conjunction with the energy requirements for various building types. Systems considered have been tested and proven. Study has been limited to evaluating only economically justifiable projects.

Impact of the systems on the basewide energy usage has been studied, based on the installation of systems having a range of payback periods less than the projected useful life of the facility.

Each renewable energy source considered has been listed and described and those promising applications are recommended for a detailed study.

RESULTS - SOLAR ENERGY

Solar energy evaluations for WSMR include domestic hot water (DHW), space heating, combination systems for DHW and space heating, space cooling, steam generation and process hot water. Shallow solar ponds, passive solar applications and photo-voltaic generation of electricity are also discussed.

The economic analyses include both ECIP analyses and Life Cycle Cost (LCC) analyses. If a project does not qualify under ECIP criteria, it is re-evaluated under life cycle cost criteria. All economic analyses include maintenance costs for scheduled replacement of the glycol heat transfer fluid as well as a one time miscellaneous control replacement cost. The results of these analyses represent the most economically feasible systems of those evaluated, as determined by the greatest SIR value.

None of the solar projects evaluated at this level of analysis qualify under either ECIP or LCC criteria. This conclusion is based on the values of SIR exhibited by each project, which are less than one (1.0), and the negative total LCC savings for each of the solar systems evaluated.

RECOMMENDATIONS - SOLAR ENERGY

Based on the study results, the cost of fuel at WSMR is not yet high enough to provide savings capable of offsetting the investment required for the installation of solar systems. However, the costs of fossil fuels are increasing and may reach levels which will make this alternative energy source more economically feasible in time.

The cost of fuel must rise to $5.80/MBtu before Institutional DHW projects will become feasible, based on an SIR value greater than one (1.0). When the cost of fuel reaches $14.00/MBtu, other DHW and Combination Space Heat/DHW systems will become economically feasible.

RESULTS - GEOTHERMAL

The assumptions used in the development of the preliminary geothermal system evaluation are consistently optimistic in favor of the geothermal system. Since economic analysis of the preliminary system shows it to be infeasible, it is highly unlikely that any other system configuration will prove to be economically feasible. This is especially true when the dubious nature of the geothermal resource is considered. Therefore, in conclusion, geothermal conversion at WSMR is infeasible and further investigation to confirm a resource or fulfill regulatory permitting requirements is not recommended.

A similar geothermal district heating system was analyzed and shown to be feasible at HWAAP in Hawthorne, Nevada (See: Basewide Energy Systems Plan for HWAAP, Hawthorne, Nevada, Final Report, Volumes I, II, and III). However, the heating season at HWAAP is considerably more severe than that of WSMR. This is evident from the comparison of the Heating Degree Days (HDD's) at the two installations. The annual HDD's at HWAAP are more than two times as much as those at WSMR

(HWAAP) = 5508 HHD's, WSMR = 2526 HDD's). Therefore, the annual heating energy requirement per square foot of conditioned building floor area at HWAAP is much higher than that of WSMR. Since the building retrofit costs are the highest single cost factor of the system (61% of the bare system cost) and the retrofit costs are directly sensitive to heated building floor area, it is clear that a location with higher annual heating loads per floor area will achieve better economic results for geothermal conversion. This observation indicates that a more severe heating climate is required for feasible geothermal conversion of a facility the size and complexity of WSMR.

RECOMMENDATIONS - GEOTHERMAL

The assumptions used, while relatively optimistic, are based on non-specific resource data. It is not recommended that further study be made at this time to develop a least cost strategy for confirming the suitability of the geothermal resource.

In a manner similar to that of Solar Energy, Geothermal Energy usage will become more economically feasible as the cost of fuel increases in the future, assuming that fuel costs will increase at a much greater rate than investment costs.

INCREMENT F OVERVIEW

This Increment F will address the analysis results of low cost energy conservation projects which fall under Facilities Engineering funding authority.

SCOPE

Increment F contains brief descriptions and results summaries for each of the low cost energy conservation projects as well as the detailed energy savings and cost calculations for each project. Weather and general assumptions utilized in the detailed project calculations are also included.

Energy conservation efforts made since 1975 at WSMR and energy conservation projects in progress and planned at WSMR also are included.

Increment A, B, and G projects and their energy and dollar savings including project implementation cost, energy savings, first year dollar savings, and Savings to Investment Ratio (SIR) of each Increment A, B, and G project are presented.

The following are also addressed:

1. Recommended operation and personnel training procedures associated with energy conservation.
2. Replacement of expendable equipment with higher efficiency units .
3. General energy savings recommendations pertaining to operation and maintenance procedures.

PRESENTATION OF INCREMENT F PROJECTS

Southwestern Energy Group has currently identified fourteen (14) projects. In addition, 5 additional projects are to be included as fallout projects from Increment A.

1. Project: Lower DHW Supply Temperature (Non-Family Housing)

   Description: Reduce the hot water supply temperature in qualifying Non-Family Housing facilities to 105°F. This measure reduces the energy to heat the hot water, as well as the standby heat conduction losses. The energy savings calculations for this project assume that flow restrictors have been installed where applicable.

Energy and Cost Analysis Results:

No. of Buildings:	66
Source Energy Savings (MBTU/yr.):	824.20
First Year Dollar Savings:	$3,635.00
In-House Cost to Implement:	$111.00

2. Project: Replace/Repair Doors and Windows

Description: Broken and/or poorly fitted doors and windows allow air leakeage in and out of conditioned buildings. Replacement or repair of these doors/windows saves energy by reducing infiltration.

Energy and Cost Analysis Results:

No. of Buildings:	14
Source Energy Savings (MBTU/yr.):	665.00
First Year Dollar Savings:	$2,868.00
In-House Cost to Implement:	$1,036.00

3. Project: Rewire Restroom (RR) Exhaust to Light Switch

Description: In Building 153, the restroom exhaust fan in the East Wing is currently wired to a single switch which is controlled by the occupants. The fan operates approximately 43 hours per week. By rewiring the fan to the restroom light switch, the operating time of the fan will be reduced, and electrical energy will be saved.

Energy and Cost Analysis Results:

No. of Buildings:	1
Source Energy Savings (MBTU/yr.):	5.50
First Year Dollar Savings:	$30.00
In-House Cost to Implement:	$76.00

4. Project: Repair/Replace Leaking Ductwork

Description: Several forced air systems at the WSMR have ductwork or vibration isolators that are leaking conditioned air. Repair or replacement of leaky ductwork or vibration isolators to stop air leakage will result in energy savings.

Energy and Cost Analysis Results:

No. of Buildings:	3
Source Energy Savings (MBTU/yr.):	153.70
First Year Dollar Savings:	$809.00
In-House Cost to Implement:	$183.00

5. Project: Exhaust Damper Installation or Modification

Description: This project prevents or decreases outside air infiltration by the installation or modification of barometric

exhaust dampers. Openings in building envelopes are used for exhausting fumes, as well as evaporatively cooled air. If not properly sealed, these exhaust openings will leak heated air during the winter, or allow outside air to infiltrate the structure.

Energy and Cost Analysis Results:

All projects had an SIR less than 1.0

6. Project: Insulate DHW Supply Piping

Description: Heat loss from uninsulated pipes can be reduced by the addition of insulation. However, this measure is only considered for those buildings that have exposed pipes of reasonable runs (more than 10 feet) and/or have high DHW temperatures (greater than 140 F). Most of the buildings at WSMR either have short DHW pipe runs or their piping is unaccessible (behind walls or imbedded within concrete).

Energy and Cost Analysis Results:

No. of Buildings:	6
Source Energy Savings (MBTU/yr.):	40.7
First Year Dollar Savings:	$173.00
In-House Cost to Implement:	$389.00

7. Project: Weatherize Evaporative Coolers

Description: Infiltration of cold winter air into buildings from unweatherized evaporative coolers (EC's) results in unnecessary energy losses. Most of the EC units at WSMR are equipped with damper insert slots to receive flat sheet metal dampers during the heating season. Some of these dampers have not been replaced after the last cooling season. In addition, it is possible that the dampers have been lost. This project will present the energy savings and costs for installing these dampers where they are missing.

Energy and Cost Analysis Results:

No. of Buildings:	5
Source Energy Savings (MBTU/yr.):	160.5
First Year Dollar Savings:	$682.00
In-House Cost to Implement:	$433.00

8. Projects: Repair Inoperable Ventilating Window

Description: The bay area of Building 21759 has ventilation windows located in the clerestory. These windows are designed to swing open due to wind pressure to ventilate the bay area during the warm months of the year. One of these windows has become stuck open, thus resulting in substantial heat loss from the building during the heating season. Repair of this situation will result in substantial energy savings.

Energy and Cost Analysis Results:

No. of Buildings:	1
Source Energy Savings (MBTU/yr.):	195.7
First Year Dollar Savings:	$1,312.00
In-House Cost to Implement:	$24.00

9. Project: Wall Crack and Hole Repair

Description: Many of the masonry walls of buildings at WSMR have cracks from irregular foundation settling. Also, holes from previous penetrations in building walls exist. These conditions allow for unnecessary infiltration of outside air into the buildings. Repair of these conditions by caulking wallcracks and plugging or caping wall holes wil essentially eliminate this unnecessary energy loss due to infiltration.

Energy and Cost Analysis Results:

No. of Buildings:	19
Source Energy Savings (MBTU/yr.):	35.4
First Year Dollar Savings:	$151.40
In-House Cost to Implement:	$327.00

10. Project: Repair Leaking Pipes and Valves

Description: At the time of the building surveys, leaks were discovered in hot water (HW), steam (STM), and condensate return (CR) pipes and valves. These leaks represent energy losses and should be repaired.

Energy and Cost Analysis Results:

No. of Buildings:	11
Source Energy Savings (MBTU/yr.):	102.9
First Year Dollar Savings:	$438.00
In-House Cost to Implement:	$436.00

11. Project: Remove Electric Hand Dryers

Description: Electric hand dryers are currently being used in restrooms, as well as paper towels in Building 1530. These electric dryers are unecessary and should be disconnected to save electrical energy.

Energy and Cost Analysis Results:

No. of Buildings:	1
Source Energy Savings (MBTU/yr.):	62.8
First Year Dollar Savings:	$367.00
In-House Cost to Implement:	$228.00

12. Project: Cover Unused Ventilation Fan

Description: Fork lifts were once used in the warehouse portion of Building 1832. A wall ventilation fan was installed to remove exhaust from these forklifts. However, no forklifts are currently used in the building. Although the fan does not currently operate, it results in heat loss due to infiltration during the heating season. Since this fan is not currently used, it can be covered with a removable weather seal until needed and save energy.

Energy and Cost Analysis Results:

No. of Buildings:	1
Source Energy Savings (MBTU/yr.):	35.0
First Year Dollar Savings:	$149.00
In-House Cost to Implement:	$45.00

13. Project: Insulate DHW Tanks (Non-Family Housing)

Description: Additional insulation of DHW tanks will save energy by reducing tank standby conduction heat losses. It is assumed that DHW supply temperatures have been reduced and that flow restrictors are in place, where applicable. This project addresses small gas and electric water heaters in the 30-100 gallon size range. Larger tanks are addressed in the repair insulation project.

Energy and Cost Analysis Results:

No. of Buildings:	76
Source Energy Savings (MBTU/yr.):	187.7
First Year Dollar Savings:	$919.00
In-House Cost to Implement:	$1,372.00

14. Project: Isolate Unnecessary DHW Tanks

Description: The DHW systems in Buildings 23626 and 1646 have storage capacities much larger than what is currently required by the acitivities in these facilities. Building 23626 has two 100-gallon DHW heaters. Building 1646 has a 130-gallon hot water storage tank. Turning off the unnecessary DHW heater in 23626, and isolation of the unnecessary DHW storage tank in 1646 will result in energy savings equal to the conduction heat loss from these tanks.

Energy and Cost Analysis Results:

No. of Buildings:	2
Source Energy Savings (MBTU/yr.):	9.2
First Year Dollar Savings:	$51.00
In-House Cost to Implement:	$133.00

SUMMARY OF ENERGY AND DOLLAR SAVINGS

The following table is a summary of the energy and first year dollar savings by fuel type resulting from implementation of the recommended (SIR equal to or greater than 1.0) Increment F projects.

The total energy savings resulting from the 14 recommended Increment F projects amounts to 2,478.4 MBtu/year. The first year savings is $11,560, assuming the 1983 fuel costs of $4.256/MBtu for natural gas, $6.702/MBtu for propane, and $5.836/MBtu for electricity.

INCREMENT F PROJECT IMPACT SUMMARY

FUEL TYPE	SOURCE ENERGY SAVINGS (MBtu/Year)	FIRST YEAR DOLLAR SAVINGS ($)
Electricity	233.0	$1,360
Natural Gas	1,982.3	8,437
Propane	263.1	1,763
TOTALS	2,478.4 MBtu	$11,560

ADDITIONAL INCREMENT F PROJECTS FROM INCREMENT A

Page ES-32 presents five additional projects recommended for implementation under Increment F. These projects were determined to be more appropriate under Increment F due to their low cost and the nature of the work requirements. The five projects will result in additional savings of 14,846.9 MBtu/yr. with a first year dollar savings estimated at $74,583. This additional energy and cost savings potential will combine with that of the other 14 Increment F projects to provide a total savings of 17,325.3 MBtu annually and first year dollar savings of aproximately $86,143.

ENERGY CONSERVATION MODIFICATIONS SINCE 1975

The following energy conservation modifications were accomplished by WSMR since 1975 or are currently in progress:

YEAR	PROJECT DESCRIPTION
1977	Improve "U" factors in Shops and Warehouses, MCA Project 272. Includes Building Nos. 420, 421, 1538, 1544, 1558, 1648, 1753, 1754, 1755, 1764,1852, 1871, 19464, 19470,

	21610, 21620, 21623, 21750, 21751, 21905, 23101, 23320, 23331, 23484
1983	Redesign Air Conditioning System in Bldg. 302.
1983	Repair Existing Boiler, Modify Controls and Install Back-up Boiler in Building 23106.
1983	"Remove and Replace Air Washers and Evaporative Coolers in the Post Area," WS-0098-82. This project includes air washers in Building Nos. 100, 102, 384, 160, 1330 and evaporative coolers in Building Nos. 155, 144, 238, 460, 503, 504, 530, 1401, 1472, 1644, 1690, 1741, 1745, 1751, 1768, 1776, 1830, 1832, 1833, 1854, and 1870.
1983	"Modify Air Conditioning System, Optical Lab, West Wing Building 1506," WS-0116-82.
N/A	Street light delamping in Family Housing area. The area was delamped 50%.
N/A	Elastomeric roofing insulation was tried and abandoned due to poor product reliability.
Current	Family Housing ECIP modifications, including ceiling/roof insulation, setback thermostats, flow restricters, incandescent kitchen light replacement, evaporative cooler, energy reduction devices.
Current	Replacement on failure of incandescent street lighting with high pressure sodium lights.
Current	"Air Conditioning for Main Section Building 1504," WS-0111-82, will modify and modernize the existing A/C System.
Current	"Air Conditioning for Second Floor of West Wing Building 1504," WS-0112-82.
Current	Modify A/C System in building 1400. Scope of Work - AE shall study existing 100 ton A/C System to determine the most economical replacement for providing the required heating and cooling in Building 1400.

PROJECTS PROPOSED BY FACILITY ENGINEERING DEPARTMENT AT WSMR

Proposed	Modify A/C System(s) in building 1676. Scope of Work - AE shall study existing A/C system(s) to determine the most economical replacement for providing the required heating and cooling in Bldg. 1676.
Proposed	A/C Study of Bldg. Nos. 21925 and 21925A. Scope of Work - Perform on-site study of Bldgs. 21925 and 21925A to determine the most cost effective and energy conserving arrangement for providing the required heating/cooling of equipment and personnel.

Proposed Replace Domestic Hot Water Equipment in Building 160 (Consolidated Mess). Scope of Work - Provide plans, specifications, and cost estimate for replacing the existing domestic hot water equipment and other related equipment and plumbing.

Proposed Replace Hot Water Storage Tank and Boiler in Building 501. Scope of Work - Provide plans, specifications, and cost estimate for replacing the hot water storage tank, boiler and associated piping and controls.

Proposed Modify High Pressure Steam Boiler in Steam Plant No. 1544. Modify Controls to State-of-the-Art.

Proposed Replace 90 Ton Absorption Chiller in Bldg. 1534 with Centrifugal Chiller.

Proposed Replace Boiler and Boiler Controls in Building 152.

Proposed Convert Boilers to Dual Fuel, Natural Gas, and DF-2 in Buildings 1506, and 1622.

PROJECTS DEVELOPED UNDER INCREMENTS A, B AND G

Refer to page ES-25 for those ECIP projects developed and recommended for implementation under Increments A, B and G.

OPERATION AND TRAINING

Three energy related areas of facility operation exist at the White Sands Missile Range in which additional personnel training would result in energy savings. These areas include:

+ HVAC control systems operation and maintenance.
+ Boiler plant operation, maintenance and tuning.
+ Utilities rate management and energy use monitoring.

Specific training courses are recommended in the report.

EXPENDABLE EQUIPMENT REPLACEMENT

Much of the existing equipment at WSMR is of standard design, having been manufactured before Industry responded to the need for more energy efficient equipment. Replacement of existing equipment, as required by equipment failure or other circumstances requiring replacment, should take into account the more energy efficient devices available at time of replacement.

ENERGY M

FINAL REPORT - AUG. 1984

DEPARTMENT OF THE ARMY - CORPS OF ENGINEERS
FORT WORTH DISTRICT - FORT WORTH, TEXAS
CONTRACT DACA63-81-C-0104

Variable Air Volume ECIP	HVAC System Modifications ECIP	ECIP to Change to Most Efficient Light Source

BUILDINGS

ECIP

BLDG. NO.	BUILDING TITLE	BLDG. FUNCT.	GROSS FLOOR AREA S.F.	ENVIR. FLOOR AREA S.F.	NO. OF OCC.	T-02300	T-02400	T-02500
P00100	POST HQ BLDG	61011	39635	35588	100	●		●
P00102	FIN ADM BLDG	61027	22300	19761	118	●		●
P00120	EXCH CAFE	74051	9103	8531	262			●
P00123	TEL EXCH BLDG	13180	11643	10413	39		●	●
P00124	ADM GEN PURP	61050	54776	51558	129	●		●
P00126	EM BK W/O MS	72111	54818	51632	135			●
P00128	EM BK W/O MS	72111	44251	42152	73			●
P00129	EM BK W/O MS	72111	30858	28495	37			●
P00143	EM BK W/O MS	72111	30858	28495	100			●
P00153	OPS GEN PURP	14131	I2134	11962	24		●	●
P00155	FIRE STATION	73010	10792	10520	24		●	●
P00160	ENL PERS MESS	72210	11886	11278	175		●	
P00163	EXCH SVC OLS	74056	12875	12012	35			●
P00236	GYMNASIUM	74034	20281	18079	15		●	●
P00250	EM SVC CLUB	74068	12758	11977	1400			●
P00254	THEAT W/STAGE	74076	10700	9340	50			●
P00260	EXCH MAIN RTL	74053	17252	16969	30			●
P00265	POST CHAPEL	74016	19625	18509	40			●
S01090	GYMNASIUM	31043	[illegible]	[illegible]	[illegible]		●	●

Y MASTERPLAN - M

ECIP	HVAC System Modifications ECIP	ECIP to Change to Most Efficient Light Source	ECIP to Replace Chillers and Add Strainer Cycle	Family Housing ECIP for Envelope Improv. and Evaporative Cooler Exchange	ECIP to Install Liquid Type Heat Extractors/Furnace and Boiler Flues	ECIP to Install Roof and Wall Insulation	ECIP to Install Storm Windows	Family Housing ECIP for DHW Insulation and Storm Windows	LOWER DHW SUPPLY TEMPERATURE	REPLACE/REPAIR DOORS AND WINDOWS	REWIRE RR EXHAUST TO LIGHT SWITCH	REPAIR/REPLACE LEAKING DUCTWORK	EXHAUST DAMPER MODIFICATION
ECIP PROJECTS									**INCRE**				
	T-02400	T-02500	T-02600	T-02700	T-02800	T-02900	T-03000	T-03100	F-1	F-2	F-3	F-4	F-5
●		●			●		●						
●		●			●		●						
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- MATRIX OF ACTI

LIGHT SWITCH	REPAIR/REPLACE LEAKING DUCTWORK	EXHAUST DAMPER MODIFICATION	INSULATE DHW SUPPLY PIPING	WEATHERIZE EVAPORATIVE COOLERS	REPAIR INOPERATIVE VENTILATING WINDOW	WALL CRACK AND HOLE REPAIR	REPAIR LEAKING PIPES AND VALVES	REMOVE ELECTRIC HAND DRYERS	COVER UNUSED VENTILATION FAN	INSULATE DHW TANKS (NON-FAMILY HOUSING)	ISOLATE UNNECESSARY DHW TANKS	KEEP LAMP SURFACES CLEAN	WEATHERSTRIPPING AND

NCREMENT F PROJEC

F-3	F-4	F-5	F-6	F-7	F-8	F-9	F-10	F-11	F-12	F-13	F-14	F-15	F-16
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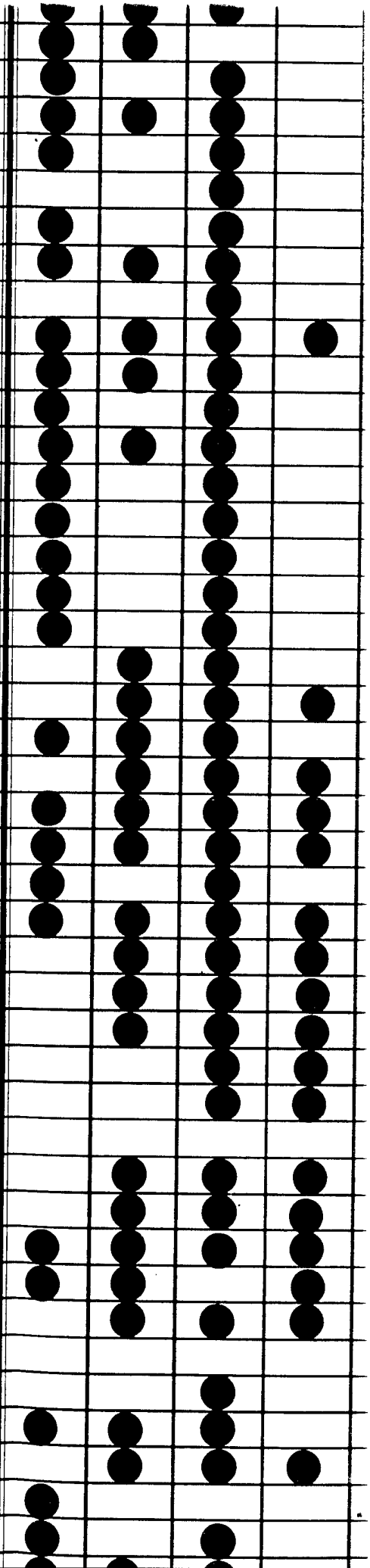
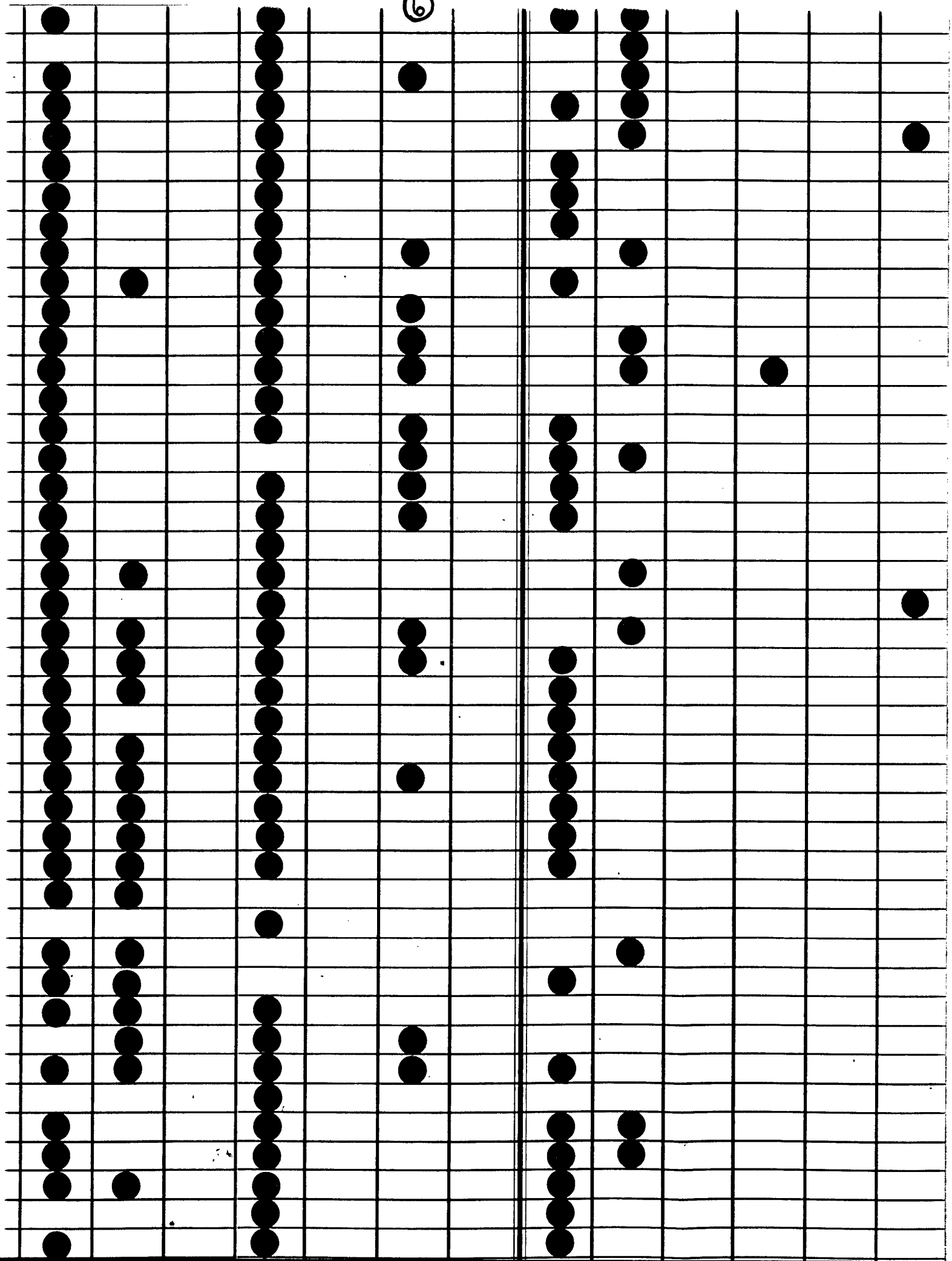
F ACTIONS

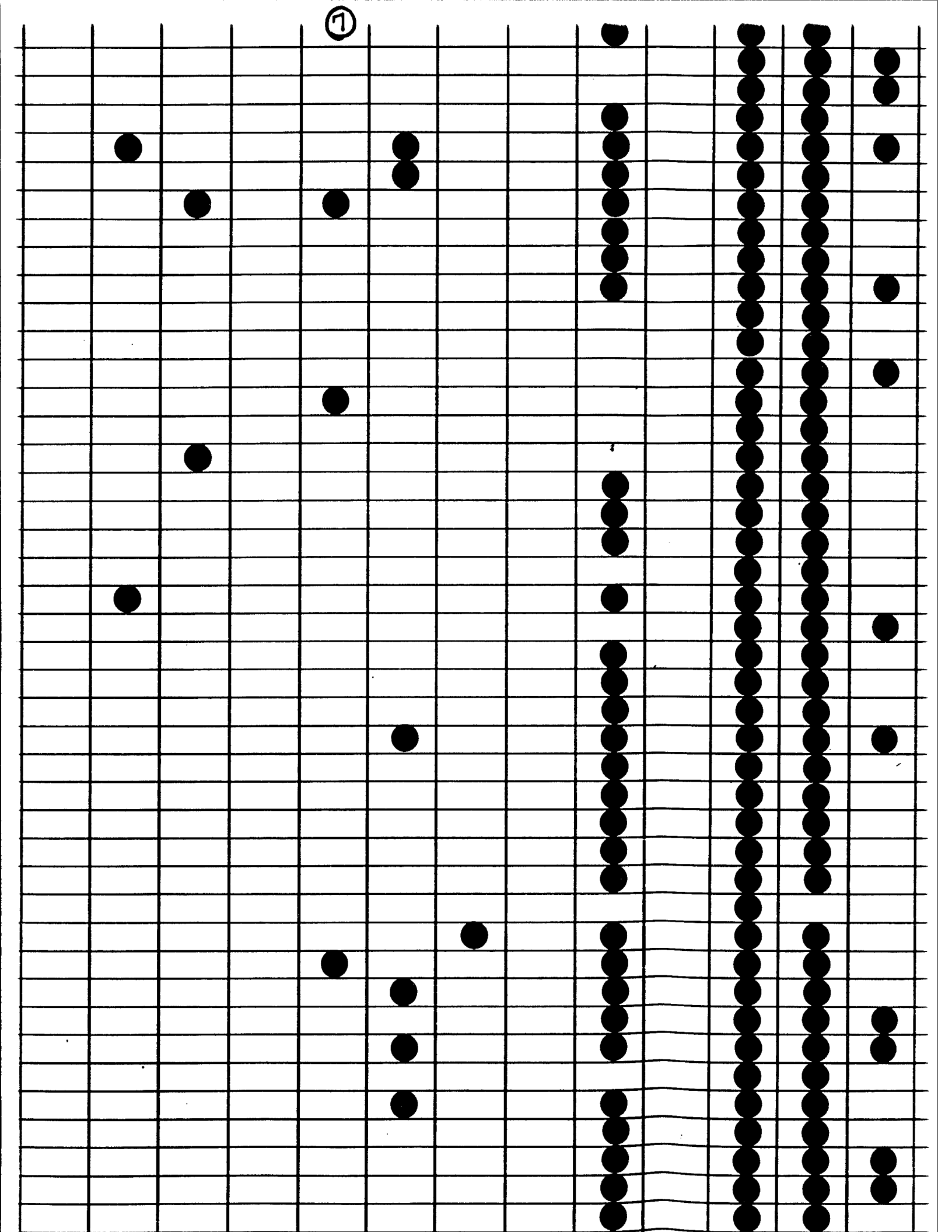
PROJECTS

DRYERS	F-12 COVER UNUSED VENTILATION FAN	F-13 INSULATE DHW TANKS (NON-FAMILY HOUSING)	F-14 ISOLATE UNNECESSARY DHW TANKS	F-15 KEEP LAMP SURFACES CLEAN	F-16 WEATHERSTRIPPING AND CAULKING	F-17 REPAIR INSULATION	F-18 SHOWER FLOW RESTRICTORS	F-19 VESTIBULES	TOTAL ENERGY SAVINGS (MBTU/YR.)	BASE (FY81) ENERGY CONSUMPTION (MBTU/YR./SQ.FT.)	PROJECTED (FY85) ENERGY CONSUMPTION (MBTU/YR./SQ.FT.)	PERCENT ENERGY REDUCTION
		●		●	●				2102.3	0.103	0.050	51.7
		●		●	●	●			1476.0	0.142	0.076	46.7
				●	●	●			1403.0	0.356	0.202	43.3
		●		●	●	●			2566.4	1.090	0.870	20.2
				●	●				2570.3	0.061	0.014	76.5
				●	●	●	●		3278.0	0.156	0.096	38.4
				●	●	●	●		3597.0	0.136	0.054	59.9
				●	●		●		1042.4	0.154	0.120	22.0
				●	●	●			1296.2	0.092	0.050	45.7
		●		●	●	●			418.0	0.124	0.089	27.8
		●		●	●		●		752.2	0.305	0.235	22.9
				●	●	●			350.6	0.319	0.289	9.2
				●	●	●			780.7	0.178	0.118	34.0
		●		●	●				705.5	0.134	0.099	26.0
		●		●	●	●			1345.4	0.228	0.122	46.3
		●		●	●				462.6	0.076	0.033	57.1
		●		●	●				890.7	0.152	0.101	33.9
		●		●	●				766.6	0.140	0.101	27.8

P00160	ENL PERS MESS	72210	11886	11278	175
P00163	EXCH SVC OLS	74056	12875	12012	35
P00236	GYMNASIUM	74034	20281	18079	15
P00250	EM SVC CLUB	74068	12758	11977	1400
P00254	THEAT W/STAGE	74076	10700	9340	50
P00260	EXCH MAIN RTL	74053	17252	16969	30
P00265	POST CHAPEL	74016	19625	18509	40
P00290	DEPN GRD SCH	73047	48543	48392	604
P00300	ELCT EQP FAC	31034	77554	68011	281
P00380	ADM GEN PURP	61050	12990	12731	47
P00384	EM BK W/O MS	72111	28629	26534	45
P00460	OPEN MESS NCO	74047	13819	13365	115
P00464	GEN INST BLDG	17120	20047	19438	40
P00501	BOQ MIL M TRN	72411	38217	33111	133
P00502	BOQ MIL MALE	72410	15456	15197	24
P00503	BOQ MIL MALE	72410	16267	15017	24
P00504	BOQ MIL MALE	72410	13596	12539	18
P00525	DENTAL CLINIC	54010	6937	6126	16
P00530	HOSP CLINIC	51020	51948	48212	60
P00880	COMMISSARY	74021	11862	10054	16
P01330	OPEN MESS OFF	74048	19511	18879	135
P01400	ADM BLDG R&D	61060	31830	27974	150
P01401	ADM BLDG R&D	61060	80795	78886	300
P01408	ADM BLDG R&D	61060	33012	32088	144
P01504	ORD ADM BLDG	61022	29397	26329	110
P01506	ELCT EQP FAC	31034	35234	31136	150
P01510	WEATHER STA	13360	3789	3728	20
P01512	ELCT EQP FAC	31034	43635	39508	94
P01526	ELCT EQP FAC	31034	32796	27488	125
P01528	LAB GEN PURP	31080	33712	29629	105
P01529	LAB GEN PURP	31080	892	892	2
P01530	ADM GEN PURP	61050	87072	80126	246
P01534	ELCT EQP FAC	31034	26378	23732	20
P01621	SIG PHOTO LAB	14130	22215	21166	82
P01622	COMM EQP FAC	31024	31168	27798	130
P01624	COMM EQP FAC	31024	44360	44360	100
P01626	SUP SV ADM BL	61023	1260	1190	10
P01644	SIG FLD MNT S	21720	20160	19854	40
P01646	SUP SV ADM BL	61023	20160	20068	80
P01676	ELCT EQP FAC	31034	14075	13364	50
P01743	GEN PURP WHS	44220	27930	27930	30
P01751	FE MNT SHOP	21910	22148	22032	36
P01782	TC ADM BLDG	61026	7100	6961	40



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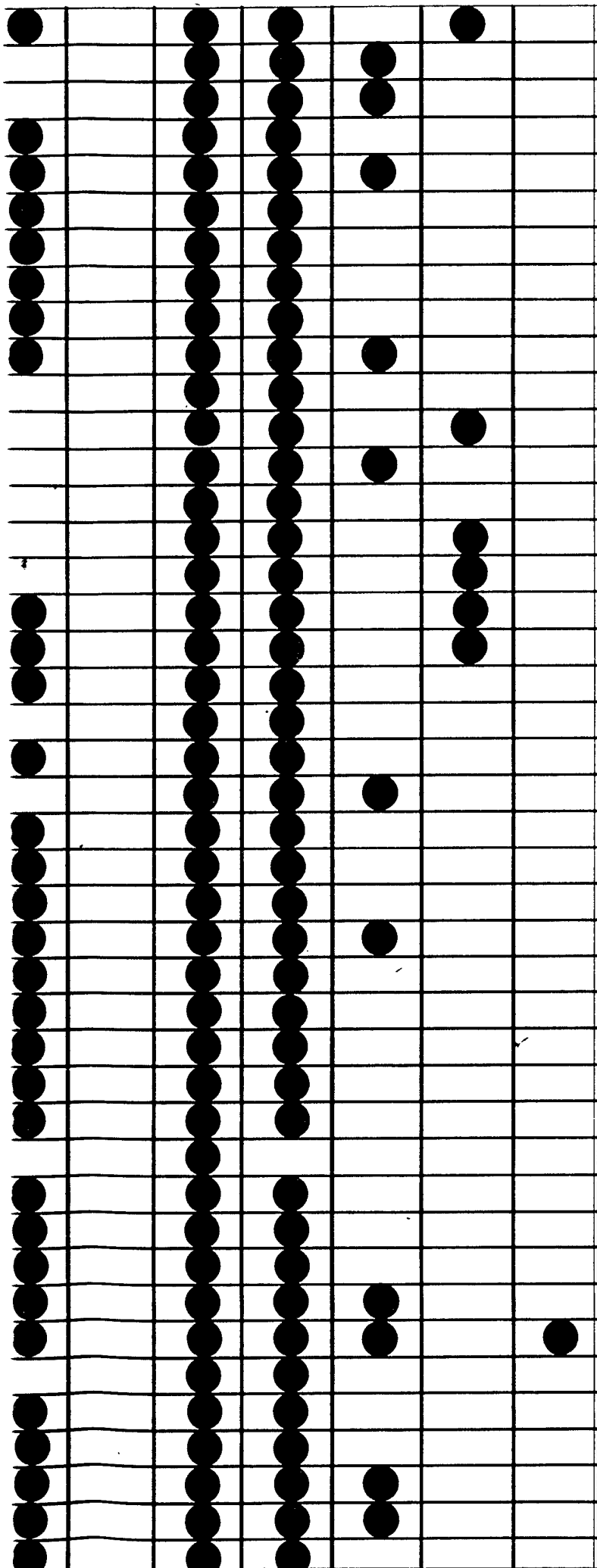
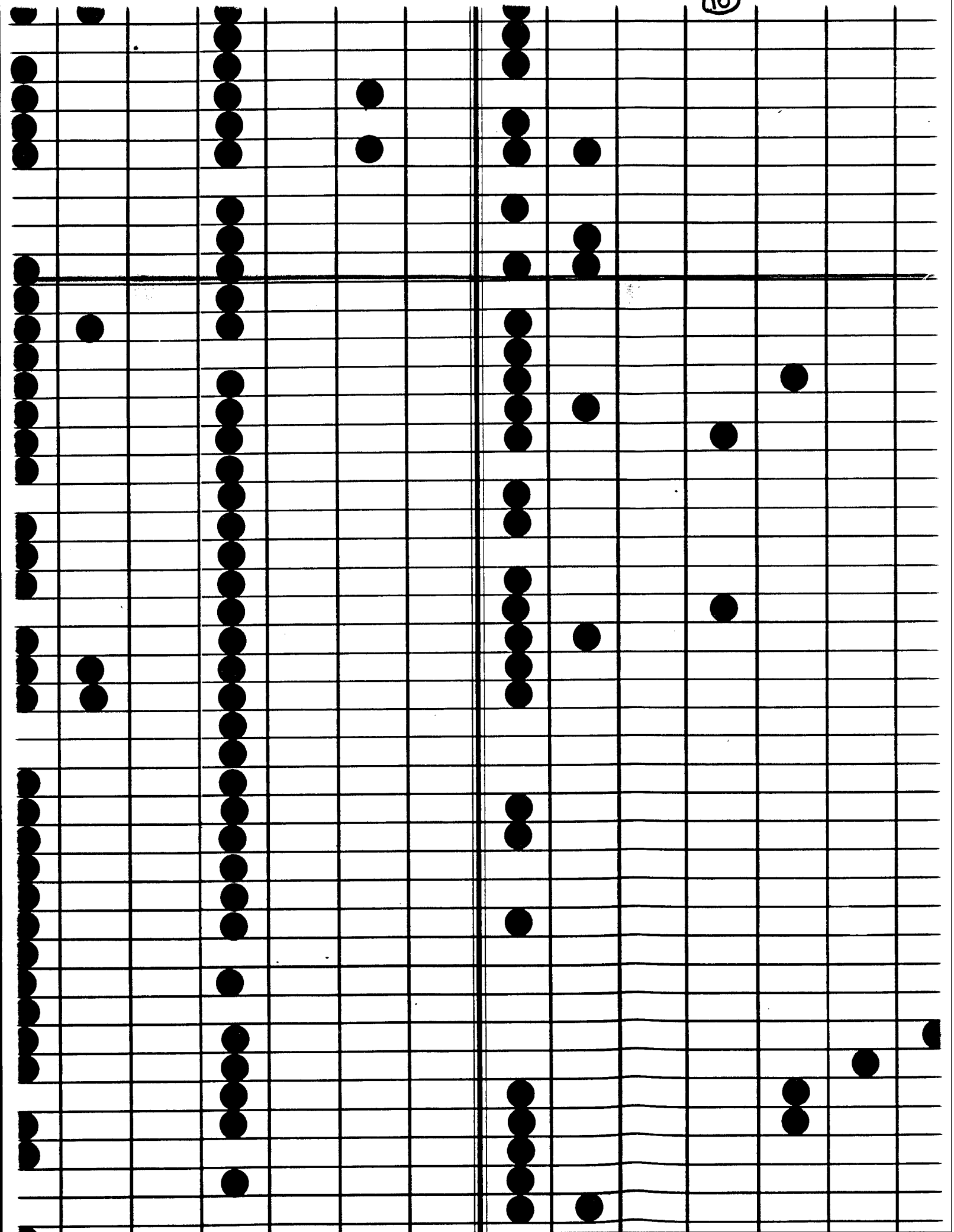
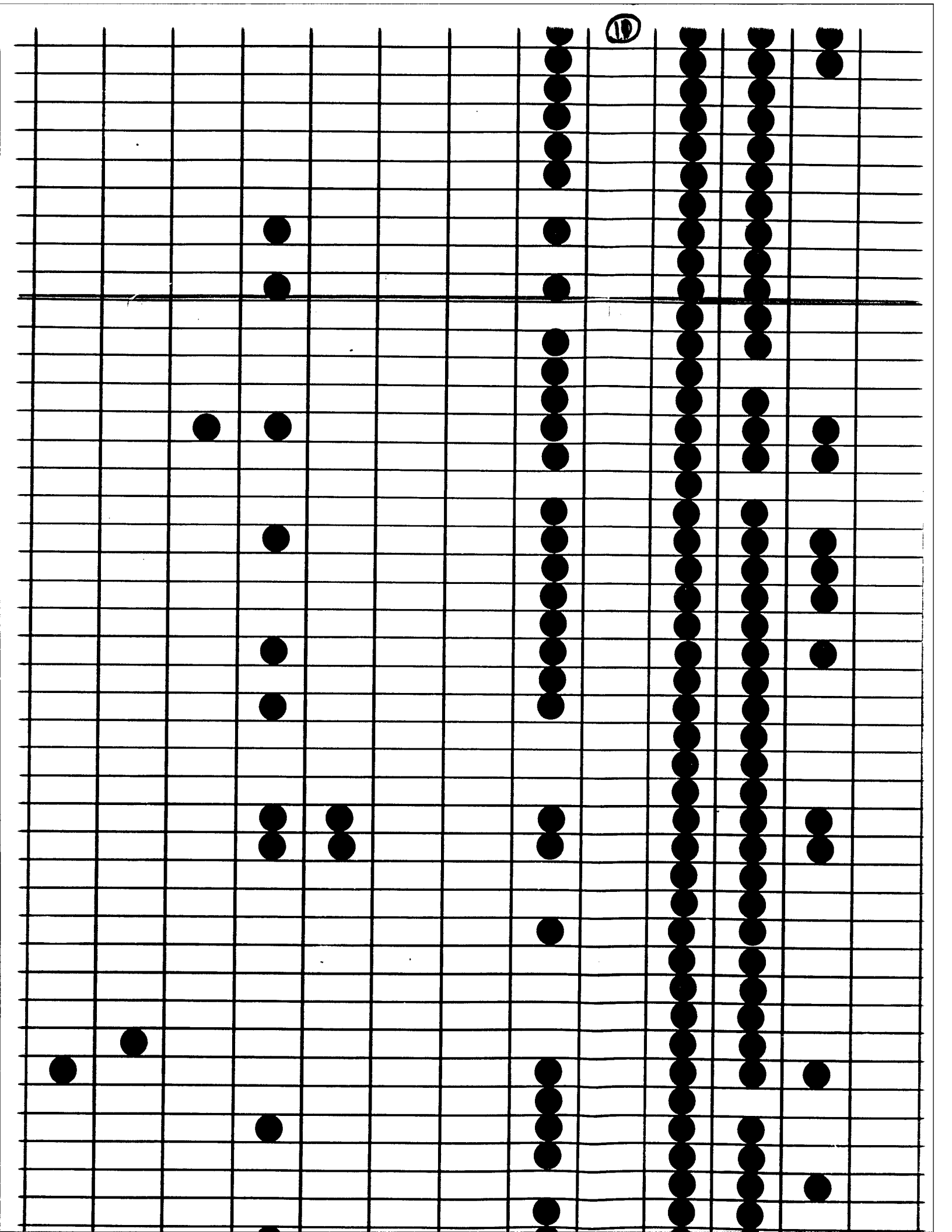
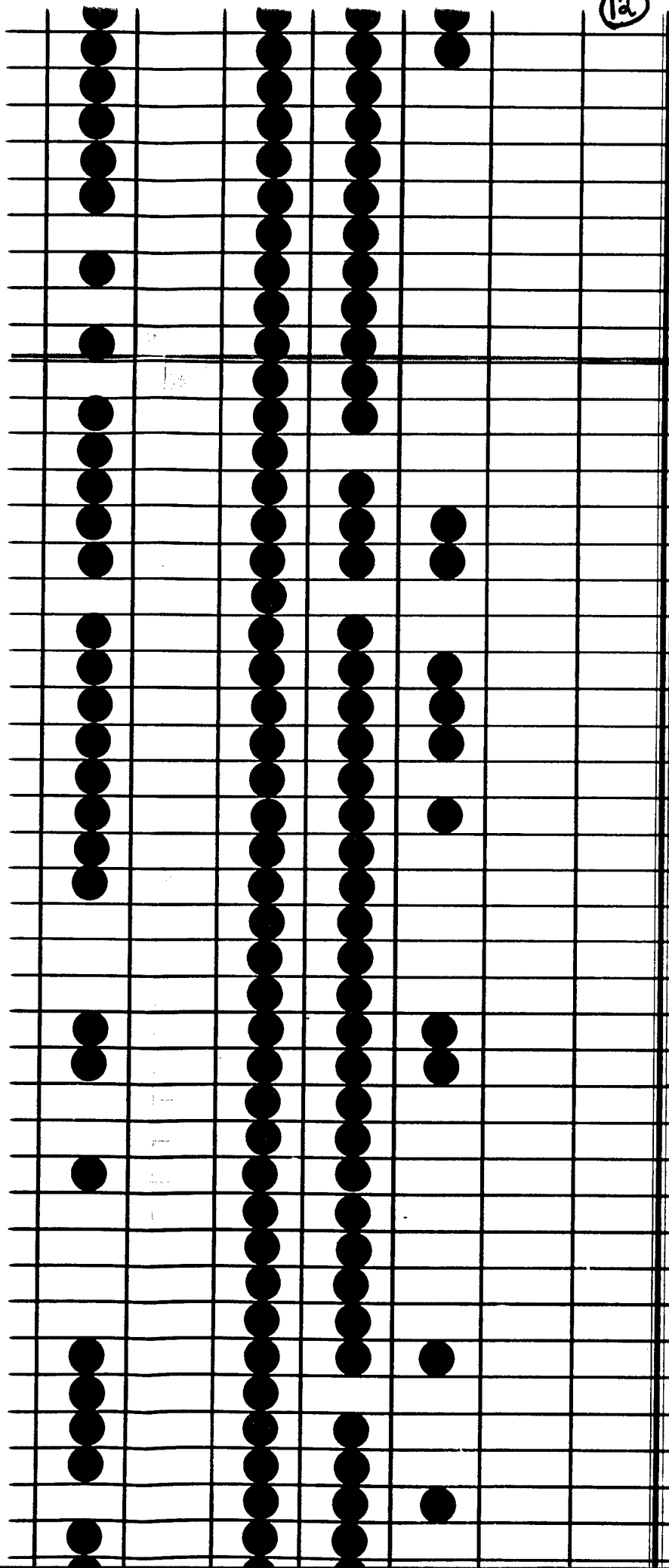


752.2	0.305	0.235	22.9
350.6	0.319	0.289	9.2
780.7	0.178	0.118	34.0
705.5	0.134	0.099	26.0
1345.4	0.228	0.122	46.3
462.6	0.076	0.033	57.1
890.7	0.152	0.101	33.9
766.6	0.140	0.101	27.8
2299.0	0.070	0.023	67.2
18534.7	1.156	0.917	20.7
539.6	0.101	0.059	41.3
1923.6	0.191	0.124	35.2
2142.9	0.242	0.087	64.2
1320.3	0.162	0.096	40.8
2470.3	0.134	0.069	48.2
866.7	0.155	0.099	36.2
1108.3	0.169	0.101	40.4
921.4	0.179	0.111	37.9
263.0	0.210	0.172	18.0
15091.0	0.548	0.258	53.0
917.1	0.884	0.807	8.7
1260.5	0.202	0.138	32.0
4092.5	0.179	0.050	71.8
5751.8	0.353	0.281	20.2
2518.2	0.142	0.066	53.7
1730.6	0.116	0.058	50.8
3543.8	0.159	0.059	63.2
308.8	0.130	0.048	62.8
6699.8	0.520	0.367	29.5
8337.9	0.592	0.338	42.9
1805.6	0.179	0.125	29.9
17.0	0.170	0.151	11.2
4159.1	0.091	0.043	52.4
2852.8	0.251	0.143	43.1
3567.5	0.452	0.291	35.6
3170.1	0.152	0.051	66.7
2370.9	0.120	0.068	43.5
21.0	0.255	0.239	6.5
746.3	0.110	0.073	33.6
766.7	0.063	0.025	60.5
1087.1	0.169	0.092	45.6
429.9	0.066	0.051	23.3
754.2	0.091	0.057	37.3

P01676	ELCT EQP FAC	31034	14075	13504	36	
P01743	GEN PURP WHS	44220	27930	27930	30	
P01751	FE MNT SHOP	21910	22148	22032	36	
P01782	TC ADM BLDG	61026	7100	6961	40	
P01788	MOTOR REP SHO	21410	9121	8963	18	
P01794	ORD FLD MNT S	21430	20640	20640	31	
P01827	GEN PURP WHS	44220	14196	14196	2	
P01830	ADM GEN PURP	61050	14196	14196	66	
P01832	GEN PURP WHS	44220	14596	14596	1	
P01833	GEN PURP WHS	44220	14161	14161	38	
P01845	GEN PURP WHS	44220	14196	13908	1	
P21225	NUC PHY CML L	31054	22071	18271	25	
P21235	LAB GEN PURP	31080	9959	8963	10	
P21756	GM FACILITY	31040	9222	8880	35	
P21759	GM FACILITY	31040	29335	28624	50	
P21903	TEL EXCH BLDG	13180	7038	6667	8	
P21925	ELCT EQP FAC	31034	13122	11414	35	
P21950	ELCT EQP FAC	31034	3650	3093	5	
P22886	ELCT EQP FAC	31034	8605	7974	30	
P23106	ELCT EQP FAC	31034	14922	12272	20	
P23108	ELCT EQP FAC	31034	6770	6156	5	
P23358	MSL ASSY - TE	21230	11736	11541	12	
P23626	GM FACILITY	31040	27291	26639	65	
P23638	ELCT EQP FAC	31034	38096	38096	16	
P23640	ELCT EQP FAC	31034	11232	10870	20	
P23654	GM FACILITY	31040	1944	1944	0	
P23656	GM FACILITY	31040	7248	7248	2	
P23680	GM FACILITY	31040	6613	4873	3	
P24064	ELCT EQP FAC	31034	22319	16602	40	
P24068	GM MNT FACILI	21210	16295	14806	18	
P24072	ELCT EQP FAC	31034	31546	29182	6	
P27170	ELCT EQP FAC	31034	5220	3991	8	
P32272	TEL EXCH BLDG	13180	3974	3556	9	
P34260	TEL EXCH BLDG	13180	3073	2774	6	
P34265	ELCT EQP FAC	31034	10012	9389	20	
P34560	ELCT EQP FAC	31034	5949	5319	15	
S00122	ADM GEN PURP	61050	9675	7975	13	
S00234	BOWLING CENTE	74012	9217	8702	208	
S00365	ADM GEN PURP	61050	4620	4462	36	
S01538	LAB GEN PURP	31080	28579	26071	35	
S01540	GM FACILITY	31040	19800	19323	14	
S01544	GM FACILITY	31040	55524	46205	50	
S01550	GM FACILITY	31040	18435	18140	40	
S01554	GM FACILITY	31040	20233	19938	40	







1087.1	0.169	0.092	45.6
429.9	0.066	0.051	23.3
754.2	0.091	0.057	37.3
462.7	0.217	0.152	30.0
494.3	0.077	0.023	70.0
1026.2	0.109	0.059	45.6
196.9	0.025	0.012	54.6
657.6	0.114	0.067	40.8
278.5	0.033	0.014	58.4
510.8	0.078	0.042	46.1
542.3	0.052	0.014	73.8
5291.2	1.903	1.664	12.6
244.0	0.421	0.397	5.8
351.3	0.131	0.092	29.2
1464.5	0.109	0.059	45.8
272.4	0.443	0.405	8.7
494.4	0.378	0.341	10.0
336.5	0.362	0.270	25.5
538.5	0.362	0.300	17.3
1385.1	0.409	0.316	22.7
355.4	0.244	0.192	21.5
246.6	0.263	0.242	8.0
1137.9	0.152	0.110	27.4
3515.0	0.220	0.128	41.9
1508.5	0.788	0.653	17.1
210.7	0.267	0.159	40.6
200.0	0.341	0.314	8.1
642.6	0.174	0.077	55.9
614.9	0.183	0.155	15.5
547.3	0.158	0.124	21.2
2492.2	0.127	0.048	62.4
414.4	0.236	0.157	33.7
233.0	1.675	1.616	3.5
92.0	0.776	0.746	3.9
648.7	0.280	0.215	23.2
874.4	1.391	1.244	10.6
338.4	0.059	0.024	58.8
243.0	0.263	0.237	10.0
26.2	0.127	0.121	4.5
1401.7	0.074	0.025	66.4
429.1	0.160	0.139	13.5
6153.9	0.466	0.355	23.8
543.1	0.199	0.170	14.8

S00365	ADM GEN PURP	61050	4620	4462	36
S01538	LAB GEN PURP	31080	28579	26071	35
S01540	GM FACILITY	31040	19800	19323	14
S01544	GM FACILITY	31040	55524	46205	50
S01550	GM FACILITY	31040	18435	18140	40
S01554	GM FACILITY	31040	20233	19938	40
S01558	ADM GEN PURP	61050	21624	19544	100
S01623	COMM EQP FAC	31024	9383	8744	60
S01648	MOTOR REP SHO	21410	14526	14526	12
S01649	RADAR MNT SHO	21730	7630	7530	26
S01650	RADAR MNT SHO	21730	7785	7664	10
S01678	GM FACILITY	31040	29898	29023	100
S01680	GM FACILITY	31040	19896	19388	60
S01690	GM FACILITY	31040	5866	5556	1
S01748	ADM GEN PURP	61050	960	960	8
S01753	ENGR FLD MNT	21820	16260	16200	13
S01790	ORD FLD MNT S	21430	15231	15231	16
S23630	ADM GEN PURP	61050	5717	5143	12
S29692	OPS GEN PURP	14131	28169	25749	82
T00117	ADM GEN PURP	61050	2250	1987	6
T00890	EXCH WAREHOUS	74055	12017	11500	12
T01768	ENGR ADM BLDG	61021	14543	13890	76

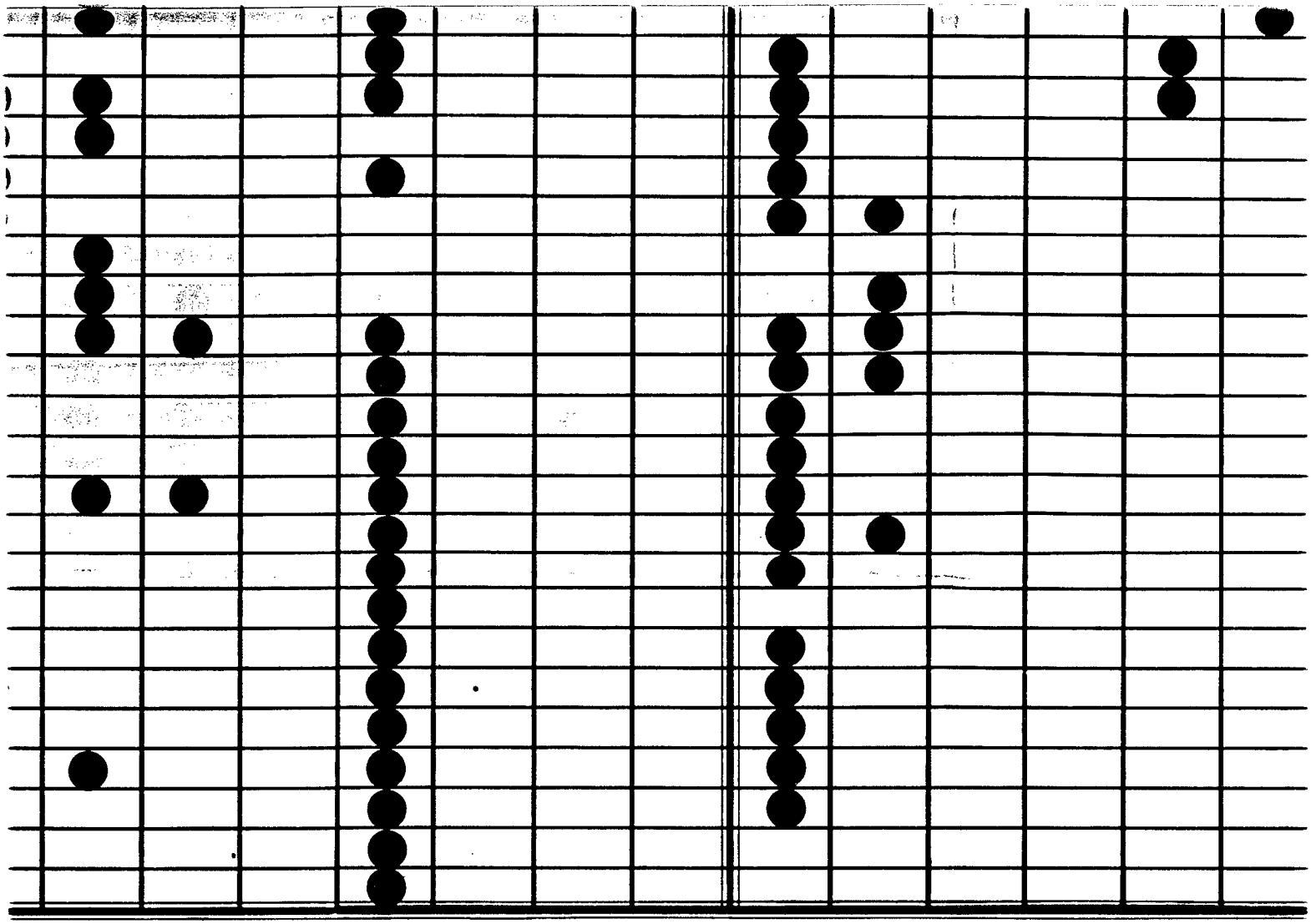
FAMILY HOUSING

ENERGY E ANALYSIS

(13) SOUTHW

In association

BLDG. NO.	TYPE	BUILDING TITLE	BLDG. FUNCT.	NO. OF TYPE	TOTAL GROUP GROSS AREA S.F.	TOTAL GROUP ENVIR. AREA S.F.
P12353	A	FH CAPE GEN	71121	1	3002	2618
P12379	B	FH CAPE COL	71122	1	2581	2204
P12355	C	FH CAPE COL	71122	6	11886	11412
P00908	D	FH COL	71112	1	1855	1855
P00910	E	FH COL	71112	1	2025	2025
P12388	F	FH CAPE LC&MJ	71123	29	54433	51562
P00928	G	FH CL & MJ	71113	3	5325	5325
P12223	H	FH CAPE CG&WO	71124	40	48200	48200
P12219	I	FH CAPE CG&WO	71124	26	34684	34684
P12322	J	FH CAPE CG	71124	67	92326	87904
P10932	K	FH CAPE NCO	71125	215	322930	307880
P00956	L	FH NCO	71115	32	57696	57696

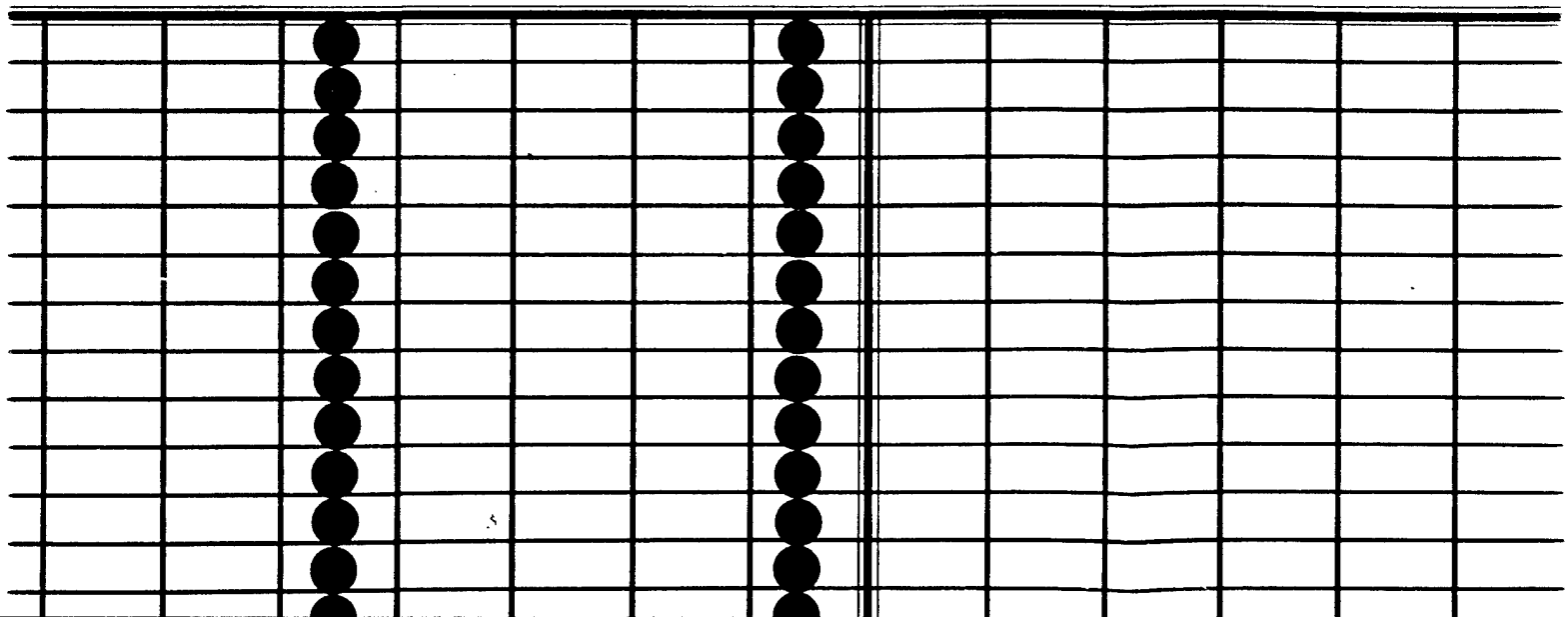


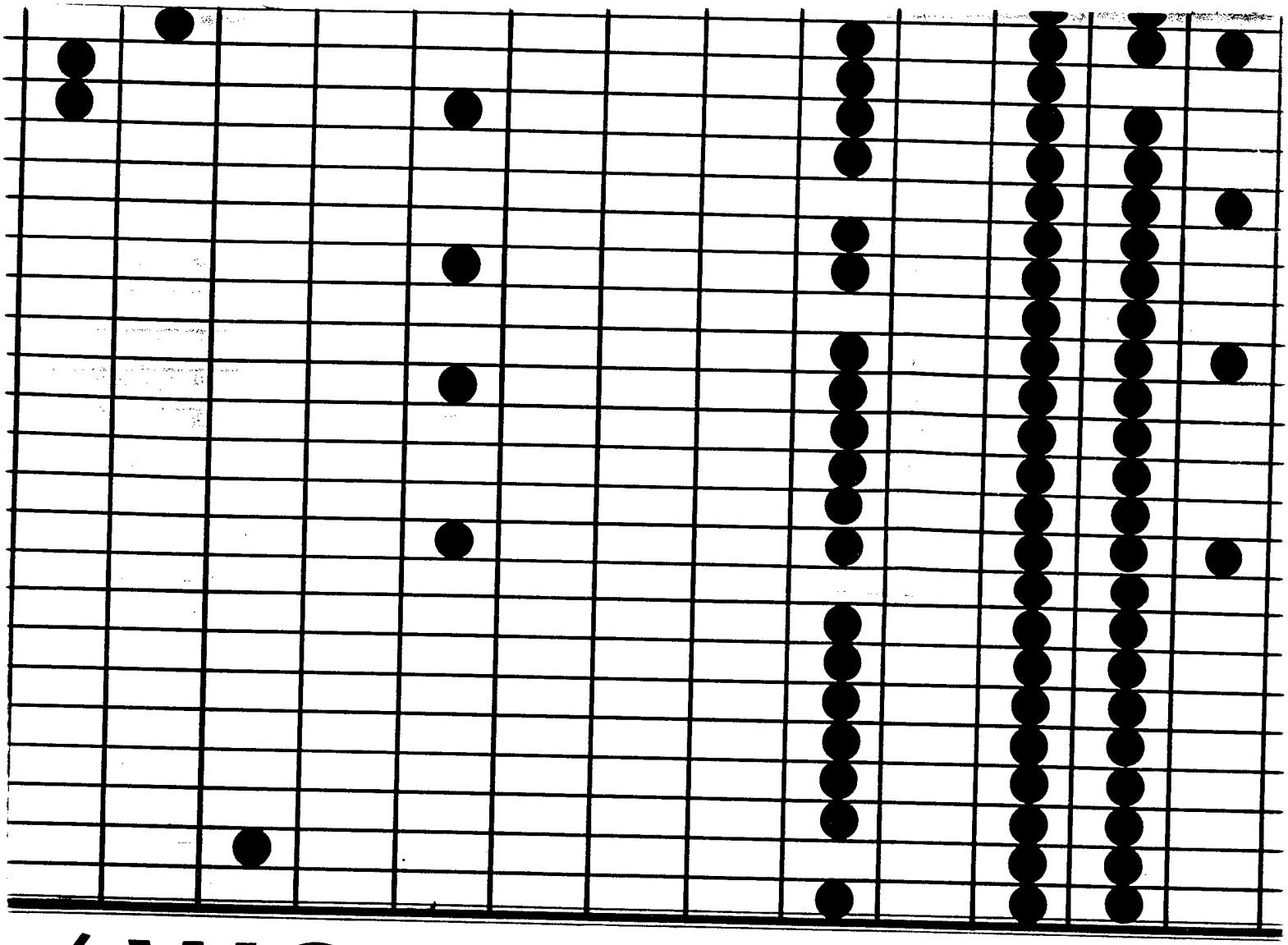
RGY ENGINEERING
LYSIS PROGRAM

(14) EEAP/ V

SOUTHWESTERN ENERGY GROUP - a division of

ssociation with Texas Energetics, New Mexico Solar Energ

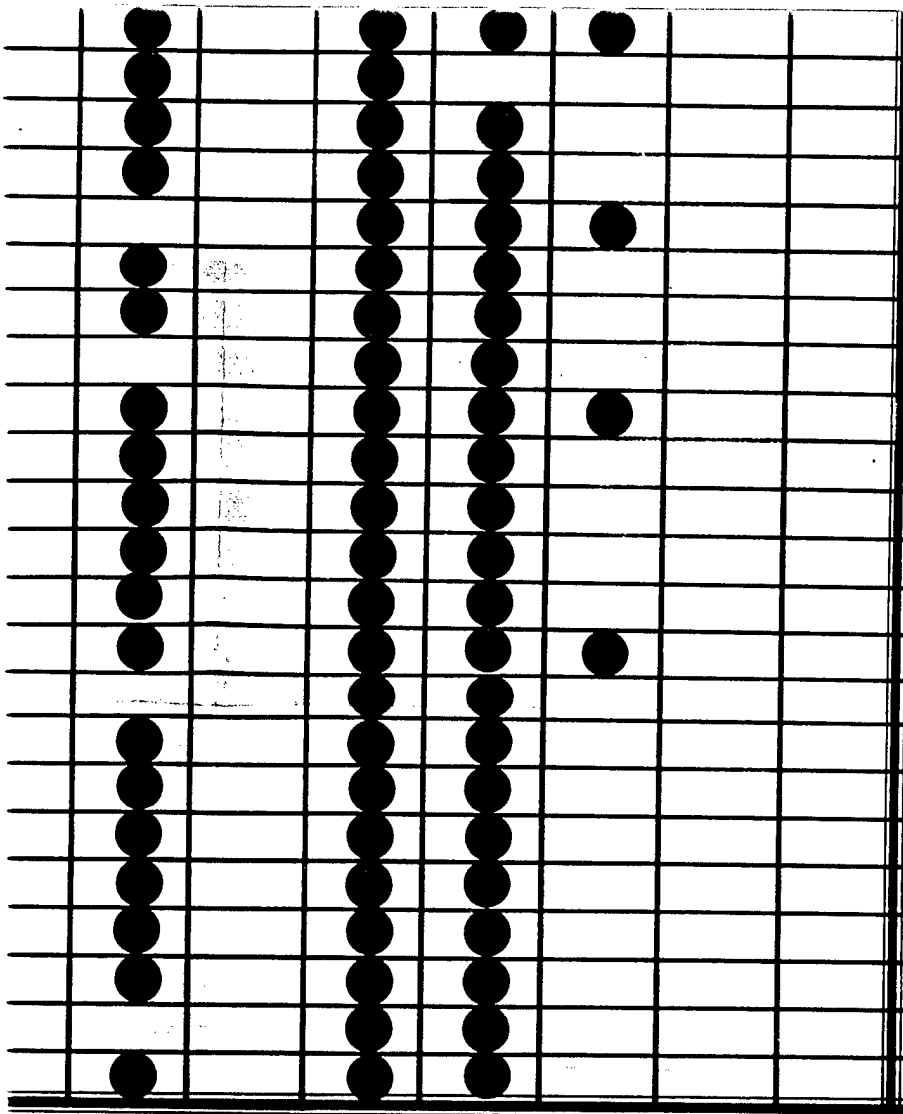




/ WSMR (15) WHITE SANDS MISSILE RA NEW MEXICO

ision of George Staten + Associates, Inc. – El Paso, Texas

lar Energy Institute at NMSU and Chilton Engineering, Chart



243.0	0.263	0.237	10.0
26.2	0.127	0.121	4.5
1401.7	0.074	0.025	66.4
429.1	0.160	0.139	13.5
6153.9	0.466	0.355	23.8
543.1	0.199	0.170	14.8
989.4	0.105	0.056	46.5
938.5	0.099	0.056	43.6
582.5	0.114	0.052	54.3
376.8	0.051	0.025	51.0
111.8	0.140	0.126	10.4
271.8	0.149	0.115	23.4
998.0	0.230	0.197	14.5
410.9	0.112	0.091	18.5
151.2	0.132	0.106	19.6
12.3	0.091	0.078	14.1
198.5	0.055	0.043	22.3
1314.2	0.164	0.078	52.6
46.3	0.061	0.052	13.4
73.3	0.202	0.199	1.3
101.5	0.159	0.114	28.3
172.6	0.043	0.029	33.3
173.0	0.117	0.105	10.1

ITE SANDS MISSILE RANGE
W MEXICO

ıtes, Inc. – El Paso, Texas
Chilton Engineering, Chartered

16

72.9	0.095	0.070	25.7
64.6	0.113	0.088	22.2
443.8	0.135	0.098	27.6
68.2	0.132	0.095	27.9
70.2	0.121	0.086	28.7
1195.2	0.113	0.091	19.5
192.0	0.129	0.093	27.9
3184.9	0.176	0.110	37.6
2192.7	0.159	0.096	39.6
5578.9	0.146	0.086	41.3
10539.7	0.137	0.105	23.8
2182.6	0.169	0.131	22.4

S01753	ENGR FLD MNT	21820	16260	16200	13	
S01790	ORD FLD MNT S	21430	15231	15231	16	
S23630	ADM GEN PURP	61050	5717	5143	12	
S29692	OPS GEN PURP	14131	28169	25749	82	
T00117	ADM GEN PURP	61050	2250	1987	6	
T00890	EXCH WAREHOUS	74055	12017	11500	12	
T01768	ENGR ADM BLDG	61021	14543	13890	76	

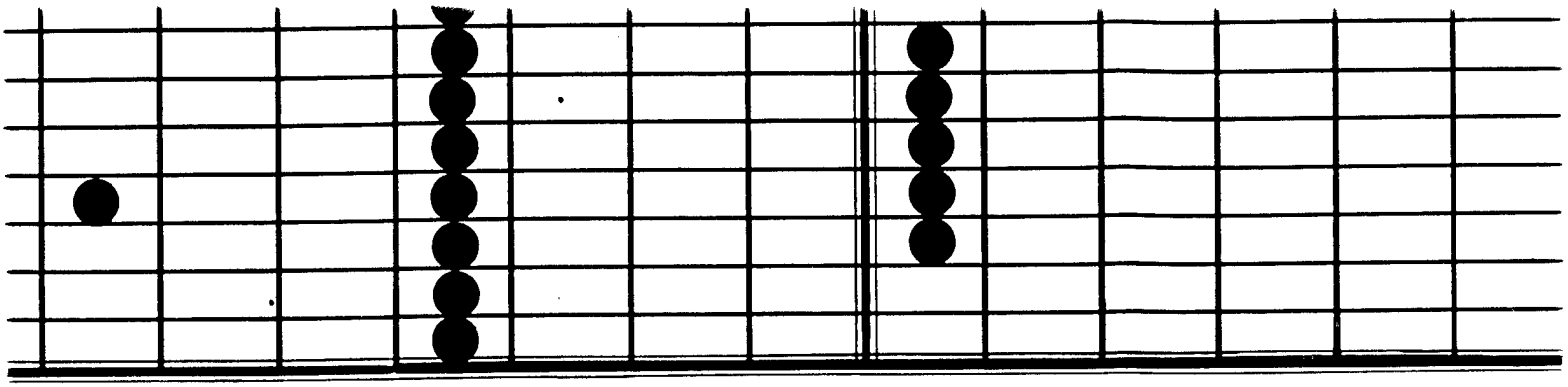
FAMILY HOUSING

ENERGY ANALYSIS

SOUTH

In associatic

BLDG. NO.	TYPE	BUILDING TITLE	BLDG. FUNCT.	NO. OF TYPE	TOTAL GROUP GROSS AREA S.F.	TOTAL GROUP ENVIR. AREA S.F.
P12353	A	FH CAPE GEN	71121	1	3002	2618
P12379	B	FH CAPE COL	71122	1	2581	2204
P12355	C	FH CAPE COL	71122	6	11886	11412
P00908	D	FH COL	71112	1	1855	1855
P00910	E	FH COL	71112	1	2025	2025
P12388	F	FH CAPE LC&MJ	71123	29	54433	51562
P00928	G	FH CL & MJ	71113	3	5325	5325
P12223	H	FH CAPE CG&WO	71124	40	48200	48200
P12219	I	FH CAPE CG&WO	71124	26	34684	34684
P12322	J	FH CAPE CG	71124	67	92326	87904
P10932	K	FH CAPE NCO	71125	215	322930	307880
P00956	L	FH NCO	71115	32	57696	57696
P11179	M	FH CG & WO	71114	118	151394	151394
P00716	N	FH NCO	71115	3	4620	4620
P10125	O	FH NCO	71115	95	117420	112290
P10163	P	FH NCO	71115	31	40145	38564
P10245	Q	FH NCO	71115	49	71148	68649
P10129	R	FH NCO	71115	30	68460	65400
P11230	S	FH CAPE NCO	71125	20	25600	25060
P11272	T	FH CAPE CG&WO	71124	33	43197	41283
P11264	U	FH CAPE NCO	71125	10	12830	12590
P11204	V	FH CAPE CG&WO	71124	12	16668	15960

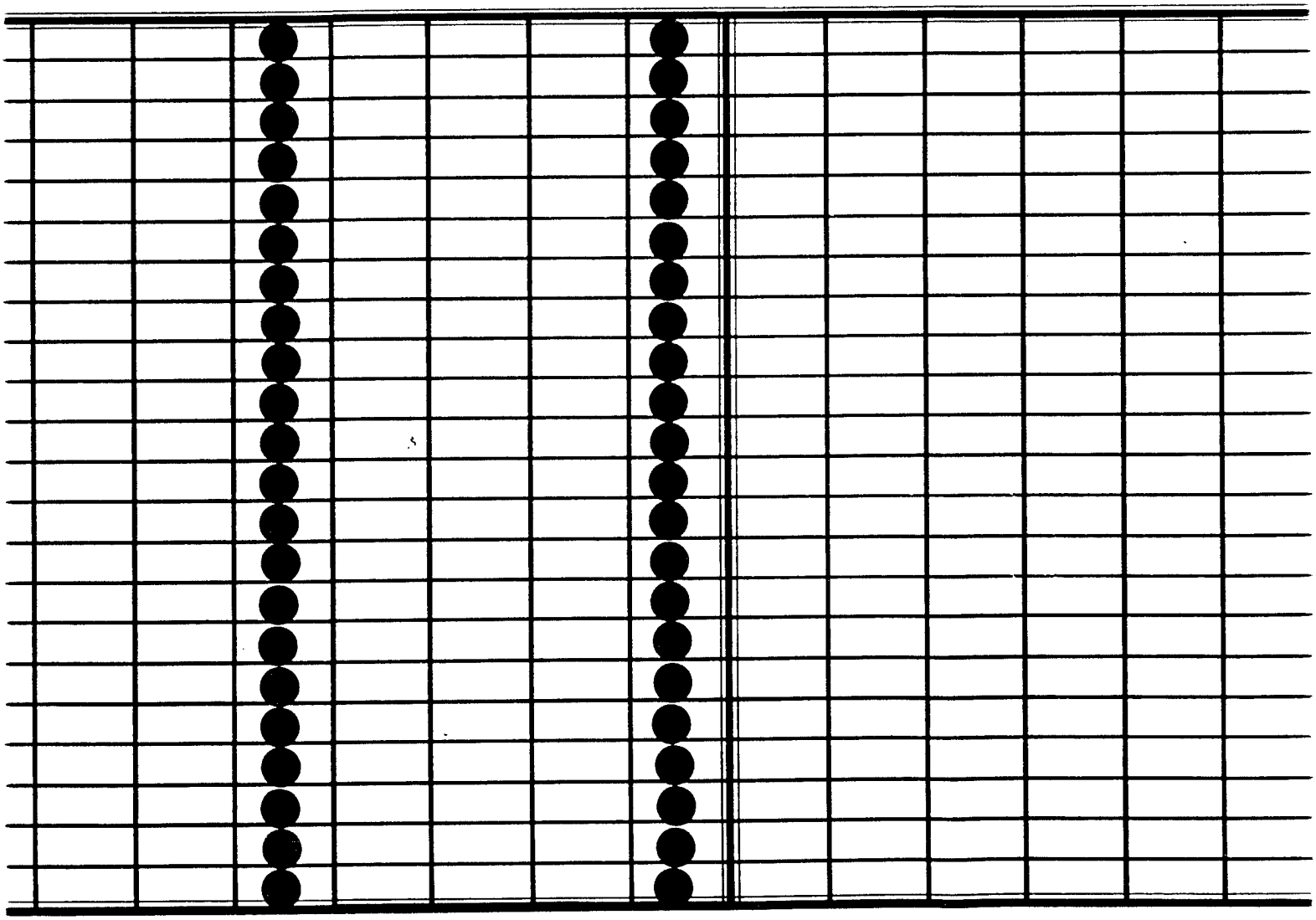


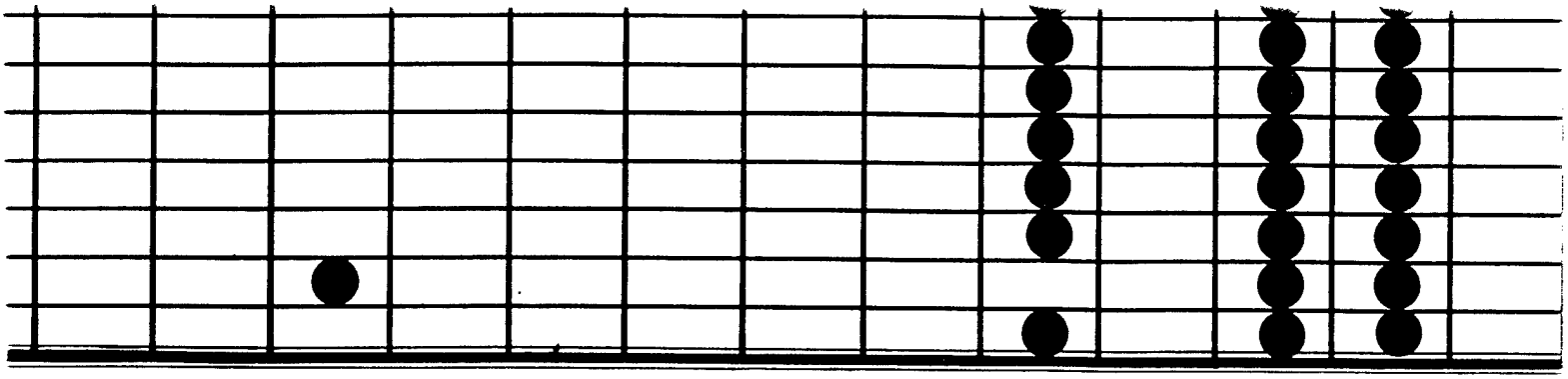
RGY ENGINEERING
LYSIS PROGRAM

EEAP/V

SOUTHWESTERN ENERGY GROUP - a division of

ssociation with Texas Energetics, New Mexico Solar Energ





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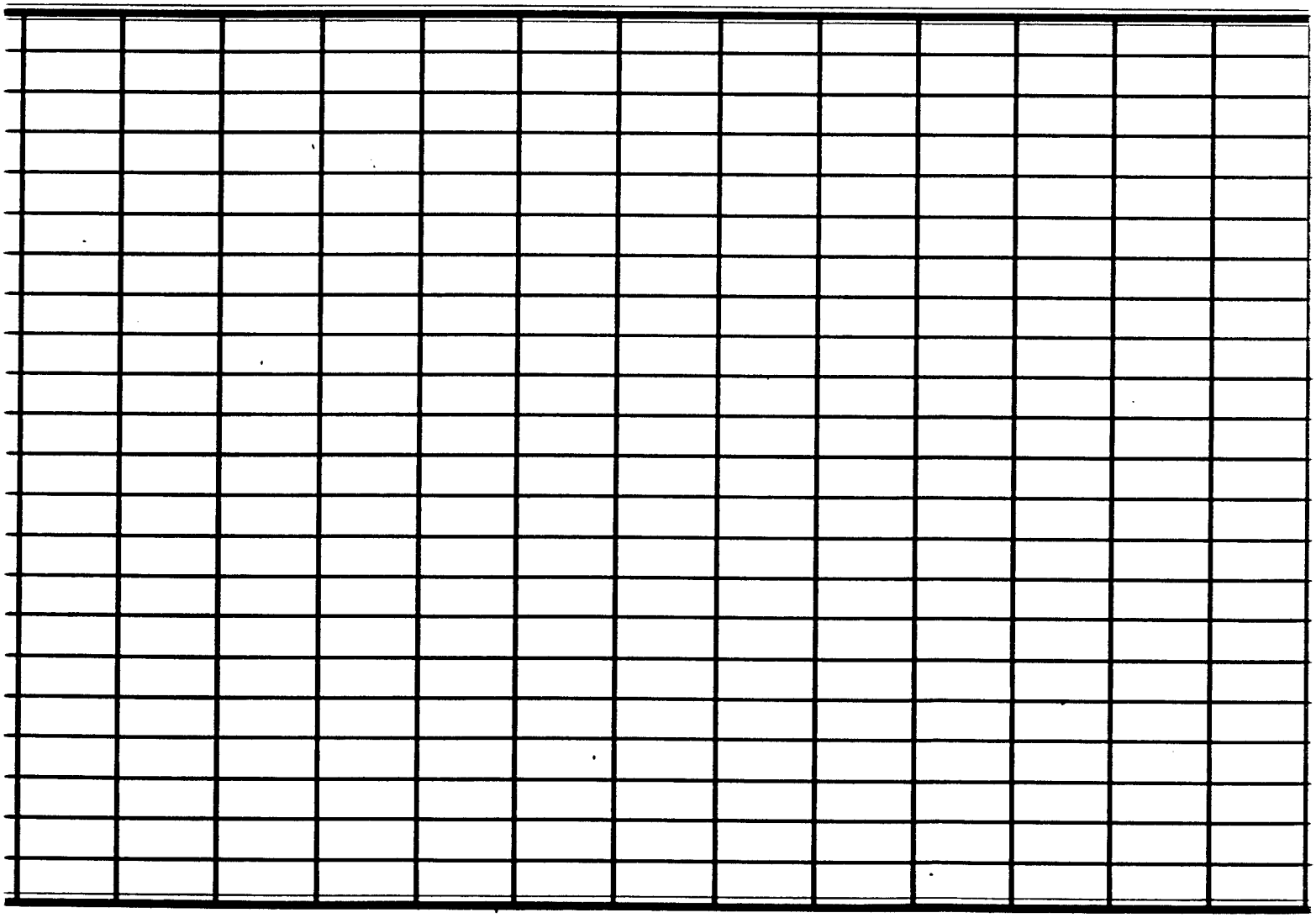
WHITE SANDS MISSILE R
NEW MEXICO

vision of George Staten + Associates, Inc. – El Paso, Texa
olar Energy Institute at NMSU and Chilton Engineering, Chai



198.5	0.055	0.043	22.3
1314.2	0.164	0.078	52.6
46.3	0.061	0.052	13.4
73.3	0.202	0.199	1.3
101.5	0.159	0.114	28.3
172.6	0.043	0.029	33.3
173.0	0.117	0.105	10.1

: SANDS MISSILE RANGE
MEXICO

s, Inc. – El Paso, Texas
lton Engineering, Chartered

72.9	0.095	0.070	25.7
64.6	0.113	0.088	22.2
443.8	0.135	0.098	27.6
68.2	0.132	0.095	27.9
70.2	0.121	0.086	28.7
1195.2	0.113	0.091	19.5
192.0	0.129	0.093	27.9
3184.9	0.176	0.110	37.6
2192.7	0.159	0.096	39.6
5578.9	0.146	0.086	41.3
10539.7	0.137	0.105	23.8
2182.6	0.169	0.131	22.4
6275.9	0.148	0.106	28.0
188.9	0.146	0.105	28.0
4528.2	0.134	0.096	28.7
1579.7	0.143	0.104	27.4
2652.9	0.136	0.099	27.4
2624.2	0.139	0.101	27.6
792.8	0.147	0.116	21.1
1186.4	0.135	0.107	20.4
402.9	0.147	0.115	21.4
419.0	0.140	0.114	18.0